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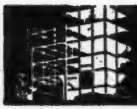

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By A. J. Stepanoff, Ingersoll-Rand Company. Deals with the hydrodynamic and thermodynamic aspects of the turboblower design. Outlines new methods of attack on turbomachine problems, and discusses the art of building turbocompressors in the United States and abroad. The author explores a number of new methods and techniques and offers a balanced picture of past and current work in the field. *1955. 398 pages. $8.00.*

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Do You Know—

► The Executive Board, at a meeting on January 13, 1954, elected as the new secretary of ASEE, Professor Leighton Collins. Professor Collins is Professor of Theoretical and Applied Mechanics at the University of Illinois. He is currently a member of the General Council, representing the Engineering Mechanics Division and has been active in ASEE affairs for a number of years. He was chairman of the Housing Committee for the Annual Meeting at the University of Illinois last June. Professor Collins succeeds Professor A. B. Bronwell, who has been appointed President of Worcester Polytechnic Institute beginning February 1, 1955.

The ASEE headquarters will move to the University of Illinois about February 1. The transition problems are being worked out and the present Secretary will provide every assistance possible in the months ahead to effect a transition.

After February 1, please address all ASEE correspondence to

Professor W. Leighton Collins
American Society For Engineering Education
University of Illinois
Urbana, Illinois.

In order to handle the selection of a new Secretary as democratically and expeditiously as possible, the President of the Society invited the Deans of all engineering colleges throughout the country to submit their nominations for the new Secretary. Invitations were also sent to Members of the General Council inviting them to send in nominations. The Executive Board met twice to sift the candidates and the President of ASEE and Secretary made several trips to institutions to explore facilities available. A substantial number of requests from engineering deans and Council members indicated preference for the Middle West as a location for the Society headquarters, since this is close to the center of the ASEE population.

► The Division of Relations With Industry will hold its annual College Industry Conference at Des Moines, Iowa, March 1 and 2, 1955. The theme will be "Current Problems Facing the Engineering Profession." All ASEE members and industrial people interested in engineering education are cordially invited to attend.

► Two Summer Schools have been authorized by the Executive Board for the Summer of 1955. These include a Summer School sponsored by the English Division and one sponsored by the Chemical Engineering Division. Both Summer Schools are being planned by their respective Divisions to present outstanding programs for teachers in these fields. They will be scheduled so as to be coordinated in time sequence with the Annual Meeting program of these two divisions.

► Again may we state proudly that our banquet speaker for the Annual Meeting this year will be the Honorable Charles Wilson, Secretary of Defense. Vice President Webster Jones at Carnegie Institute was instrumental in getting Mr. Wilson to accept this appointment.

► The Divisions and Committees of the Society are actively at work planning their annual meeting programs. From the vigorous reports of activities which we are receiving, we can predict one of the outstanding Annual Meeting pro-

grams of all times. You will definitely want to reserve the dates, June 20–24, and plan to bring the family for a profitable meeting and a pleasant vacation. There is no better vacation land in the country than the scenic mountains of Pennsylvania around State College, Pennsylvania.

► Proposals have been submitted to the National Science Foundation for two conferences and a Summer Institute. The Summer Institute will deal with thermodynamics as viewed from the vantage point of the physicist, the chemist, the chemical engineer and the mechanical engineer. Its objective is to bring together the widely divergent methods of approach and to explore the possible common ground in handling these subjects. This is one area where cross fertilization of different viewpoints might yield very substantial returns in terms of improvement of subject matter for teaching purposes. A closed conference of leading authorities in this field will be held at Purdue University. This will be followed by a conference open to ASEE membership either prior to or following the ASEE Annual Meeting at Pennsylvania State University.

One of the two conferences would deal with the coordination of subject matter in electricity and magnetism at the sophomore and junior levels, as taught by physics and engineering departments. There has always been a very substantial overlap in subject matter and it seems that better coordination here might achieve substantial returns in terms of better utilization of time. A closed conference at Lehigh University on February 14–16, 1955, of leading physics and engineering educators will provide material for the ASEE Annual Meeting Program.

A similar conference dealing with the teaching of mechanics at the sophomore and junior levels, looking toward a better coordination of subject matter between physics and engineering departments, is contemplated to be held at New York University. This conference will be the basis of joint meetings of the Physics and Engineering Mechanics Divisions. Proposals for the Summer Institute in thermodynamics and the above two conferences have been submitted to the National Science Foundation for financial support.

► Again may we remind you that the annual Mid-winter meeting of the Engineering Drawing Division is scheduled for January 27–29, 1955, at the University of Tennessee. A challenging three day session of technical papers and inspection trips, including a trip to Oak Ridge National Laboratories is being planned.

► The papers presented at the Solid State Physics Summer Institute, held at Carnegie Institute will be published in book form by John Wiley and Sons. An announcement will be published in the Journal when they are available. Also the papers presented at the Northwestern University conference on Nuclear Science in Engineering Education will be either published in separate book form or appear as a supplement in the Journal of Engineering Education.

► This is my last "Do You Know" column before moving on to Worcester Polytechnic Institute. May I express my hearty appreciation for the wholehearted cooperation which I have received from the officers and members of ASEE during the past eight years. It has been an exceedingly busy time, but packed with unforgettable experiences and pleasant associations. I look forward to continued active participation in ASEE in the years ahead.

Will see you at the Annual Meeting.

ARTHUR BRONWELL

The Pennsylvania State University

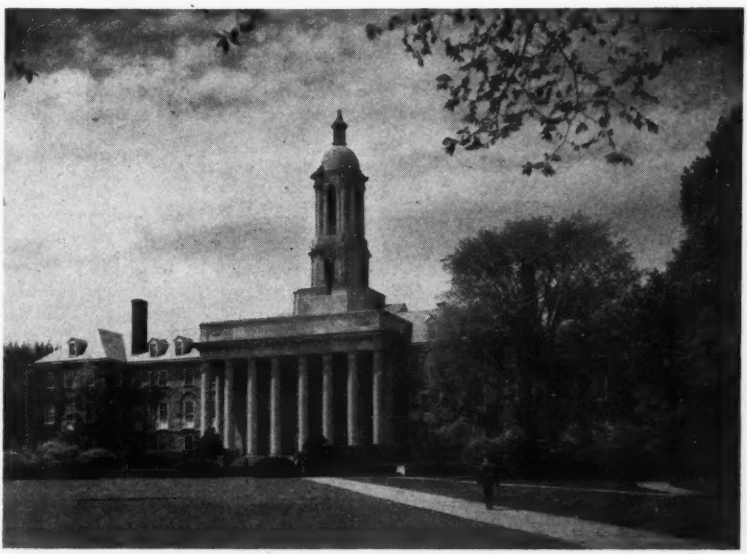
The Pennsylvania State University, where the American Society for Engineering Education will meet from June 19 to 24, will be in the midst of its Centennial Celebration when the meetings open.

The Centennial will be inaugurated with a birthday party on Feb. 22, the 100th anniversary of the granting of the charter; will bring President Dwight D. Eisenhower to the campus to deliver the Commencement address on June 11; and will terminate later in the year with a conference on higher education.

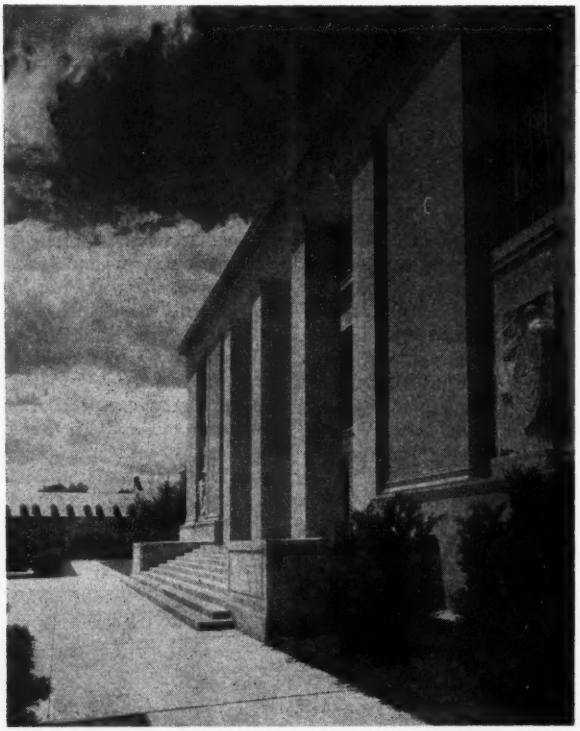
Originally chartered by the Pennsylvania Legislature as The Farmers' High School of Pennsylvania, the institution opened its doors to 69 students in February, 1859, and 119 had enrolled before the end of the year.

These students ate, slept, and went to class in a still-incomplete five-story building—the first Old Main. There were just four faculty members.

In the words of the charter of the institution, it was designed to give young men "a knowledge of the English language, grammar, geography, history, mathematics, chemistry, and such other branches of the natural and exact science as will conduce to the proper education of a farmer." This practical type of instruction marked a new concept of education.



OLD MAIN, administration building, is the center of activities on the Pennsylvania State University campus. The original building was constructed nearly 100 years ago, then replaced in 1929–30 by this structure.



FRED LEWIS PATTEE LIBRARY at the Pennsylvania State University was built in 1938 and recently was greatly expanded.

On May 1, 1862, the institution was renamed The Agricultural College of Pennsylvania, a name which recognized that its work was of collegiate level. Two months later, on July 2, President Abraham Lincoln signed the Morrill Land-Grant Act of Congress. This provided for granting public lands to the states which would use the income from them to establish institutions of higher learning where "the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

To a large extent this was already the objective of The Agricultural College of Pennsylvania. Less than a year later, on April 1, 1863, the Pennsylvania State Legislature declared that the Morrill Act "is hereby accepted by the State of Pennsylvania with all its provisions and conditions and the faith of the State is hereby pledged to carry the same into effect." The Legislature then designated Penn State as the Land-Grant College of the Commonwealth.

The College enlarged the scope of its instruction to include the "mechanic arts" and other subjects, admitted a few women

students, and gradually increased its enrollment and enlarged its physical plant. In 1874 it was renamed The Pennsylvania State College, the name it was to be known by for the next 79 years.

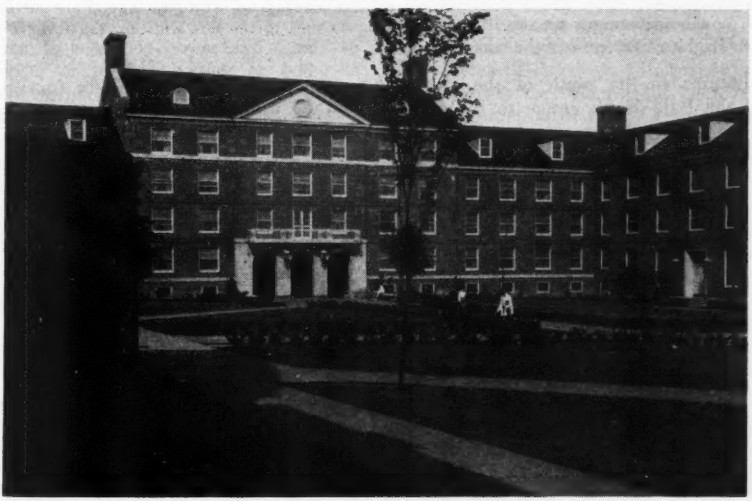
In 1953, the name was changed to The Pennsylvania State University. The institution had been a university in fact, if not in name, for many years. Its Graduate School had been established in 1922, but graduate work had been offered earlier.

Today, The Pennsylvania State University offers 59 curriculums, many of which have several options, through the following undergraduate colleges: Agriculture, Business Administration, Chemistry and Physics, Education, Engineering and Architecture, Home Economics, The Liberal Arts, Mineral Industries, and Physical Education and Athletics.

Besides resident instruction, the University has two other main functions: extension and research. Its extension program offers class instruction, correspondence instruction, and informal instruction throughout the State. Its research program, which began with a few dollars spent on nursery stock, has developed into one which costs more than $6,000,000 annually.

Thus the University grew from an original enrollment of 119 to a student body of 14,271 in the fall of 1954; from a faculty of 4 to a resident instruction faculty of 1400; from an educational program which offered 40 courses to one which offers more than 3000; from a physical plant of one building with facilities for 400 students to a physical plant of 140 buildings valued at $68,000,000; from an institution which granted 11 degrees in 1861 to one which has granted a total of 55,868 degrees since the founding of the University.

The Pennsylvania State University, which in 1953–54 ranked 11th in the Nation in full-time enrollment, is located in the borough of State College, directly in the center of the State. With the Seven



THOMPSON HALL is one of seven units comprising the West Residence Hall area at the Pennsylvania State University. The area was completed in 1950. Members of the American Society for Engineering Education will find accommodations here, as well as in other modern residence halls.

THE PENNSYLVANIA STATE UNIVERSITY and the borough of State College, Pa., are situated in this picturesque setting. Mount Nittany is seen to the left while in the foreground U. S. Highway 322 crosses the campus.

Mountains to the south of the campus and the Bald Eagle range to the north, the University is situated in an area of beautiful mountain scenery.

The main campus includes 236 acres, with a golf course and athletic fields of 153 acres adjoining the main campus to the west, and agricultural experimental plots totalling 3238 acres extending to the north and east.

When the American Society for Engineering Education meets at Penn State in June, Dr. Milton S. Eisenhower will be completing his first five years as president of the University. He assumed the presidency on July 1, 1950 after serving as president of Kansas State College of Agriculture and Applied Science from 1943 until 1950.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University
State College, Pa.

Engineering Education in Russia

By M. H. TRYTTEN

Director, Office of Scientific Personnel, National Research Council, and Consultant to the Engineering Manpower Commission of Engineers Joint Council

It is indeed fitting at this time in a meeting called to consider professional matters to give attention to the state of education in the specialized lines of study in Russia.

It has long been a copy book maxim that "knowledge is power." Perhaps we have always held that this is so. But it has remained for the recent years to demonstrate the crushing force of this truth. As mankind has gained more knowledge of nature and its secrets, the power at his disposal by manipulating the secrets of nature has increased by geometrical proportions. That power, like all power, we have learned, can be metamorphosed by simple means from one kind to another, from physical power to technological power, to economic power and finally to political or military power or both, as never before in the history of the world.

It was the United States that demonstrated dramatically the truth of this statement in World War II. Prior to 1941 the United States was the least military of all the great powers. Our military establishment was pitifully small in the years after demobilization immediately following World War I. In the year or two prior to Pearl Harbor, when we were again mobilizing, our ground forces were small, practically without equipment, and we had done very little to bring up to date what we had. We were, in fact, a peace-minded country caught with very little preparedness for war and yet faced with the greatest of all wars.

In the ensuing six years this nation built and equipped the greatest military force in its history and brought to bear a technological power which created and produced in quantity the most devastating military equipment ever known, by a large factor. All of this was done by the use of technology produced and developed for peacetime uses but readily adaptable to military needs. The secret weapon of this phenomenal performance was quite simply a corps of scientists, engineers, management experts, and other specialists whose knowledge was the nation's power in time of need. The nation triumphed because of its highly trained personnel.

It is, of course, not necessarily true that history will again repeat itself in the same way in any future emergency. But there seems little reason to suppose that in any power formula for the future the role and function of highly trained manpower will not again be of the highest importance. The strength of a nation is not measurable by corps, divisions, or battleships in any dominant sense. Its technological power is and will be of the greatest importance. And this is only to say that its corps of specialists, and its means of training more, will be as significant in measuring its power potential as any factor, and more important than almost any other factor.

Local Control of Education

It is particularly appropriate that this subject be one of concern to a great professional society in this country, since we as a nation do not have a central national agency to create educational policy and to provide for its implementation. Educa-

* Presented before the Fall Meeting of The American Society of Mechanical Engineers, September 10, 1954, Hotel Schroeder, Milwaukee, Wisconsin.

tion has been traditionally decentralized to a high degree. It is locally administered and is responsive to local control and local attitudes. Thus it is of the greatest importance that local understanding of the plan of education in the national life and in the national interest be disseminated by groups who are in a position to appreciate it.

This local control of education may have been our greatest strength in the past. It may, however, become our great weakness in the future unless greater awareness of the importance of education is developed at the local level.

It may have been our greatest strength in the past because education in America has always been a response to a peculiar deep seated desire on the part of the American people. Perhaps it was part of the reactions of the immigrants who came to a country limitless in resources and vibrant with high hopes of the future, to think in terms of better educational advantages for their young. Perhaps it was part of the concept of democracy that each individual should have the opportunity to better his station in life and realize his highest potentialities. At any rate, whether it was a private school dependent on free will giving or tax-supported public institutions dependent on the will of the people through their representatives, our schools have fared well and have grown strong.

As a result, probably not consciously anticipated fully in the minds of most people, the nation itself has grown strong. The flow of young people through the professional schools has given to the nation a powerful annual transfusion of trained minds who have found their places in our great industrial and other organizations to help create and develop the technological civilization we enjoy.

However, the boons of the past can not be taken as guarantees of the future. If a locally controlled and locally responsive educational system is to serve national needs in a modern world, local attitudes and local considerations will not be enough. Much has happened to our educational system in the last few decades. The great increase in school enrollments and the consequent concern for the students who do not intend to go on to college has had its effects in focusing attention on the needs of terminal students. Local needs and local influences have been increasingly felt. There is grave concern that in so doing our schools have been increasingly neglectful of those who plan to go further into college and the professions. There is growing concern that fewer of our high school graduates are prepared to go on to the rigorous curricula of the specialized branches. The national interest may have suffered. In a world where power is a matter of greater and greater moment to the United States, the power that resides in our technology and hence in our national resources of trained personnel must be a concern of all who are influential in shaping our educational effort.

The Russian Effort

It is considerations of this kind which make more significant an examination of the Russian effort in technological education. In Russia the role of technology and of technological education as the basis of economic and military power have never failed to be consciously understood. Furthermore, the Russian state has been in a position to implement this point of view from the top down. In contrast to our system where our motivation in the support of education has been the benefit of the individual, there it has been for the state and for the purposes of the state alone.

It is this contrast which stands out in the consideration of the two educational systems. The American tradition is one of deep concern for education because of the opportunities it gives to the individual to realize his own best potentialities. The national needs for the products of the system have been less consciously motivating. Our highly trained personnel has come about almost as a by-product. In Russia the interest has been consciously national and has arisen from the realization that

education and training are necessary to the growth of their power position. The benefits to the individual have been by-products.

In pre-revolutionary days educational opportunities in Russia were indeed limited by comparison with those in other Western countries or with the United States. Before the first World War the United States, with a population about one-third smaller than that of Russia, had a secondary and elementary school enrollment almost twice as large. American universities and colleges had four times as many students as did Russian schools. In 1914 in Russia only about 8 million children attended school, while probably as many as 30 million remained illiterate. In many Asiatic provinces of the Russian empire less than 3% of the population was literate.

Right after the Revolution of 1917 an effort was made to correct this shortcoming, and educational opportunities expanded somewhat, although quite modestly. During the 20's Soviet education was turned into chaos. Under the impact of ideological dogmatic preconceptions and under the influence of extreme ideas of Western liberal educators, Soviet education became highly experimental and an extremely permissive system. Learning by doing was carried to the point of the withering away of schools. The standards of scholarship deteriorated to an unbelievably low level. The expansion of secondary and elementary school enrollment was at a virtual standstill. Training of the professional both in numerical and qualitative terms was at a point of stagnation.

From about 1930 the emergence of an industrial order brought about a drastic change. As the theory of withering away of state, of law, of school began to be revised, we see the restoration of the traditional school, of traditional methods of teaching, with heavy stress on the teaching of mathematics, the natural sciences, physics and chemistry. As complex technology began to emerge under rapid industrialization, as bureaucratic power structures began to emerge and consolidate power in their hands, the leaders began to stress the key role that education of the specialist must play in the development of the communist state. National power, economic power, the power of the state began to be associated with specialized professional know-how, with the regular cadre of specialists.

Great Changes Made

Great changes indeed have been made during the last 25 years. Elementary school has been made compulsory. It is now the Russian boast that seven-year schools are essentially universal, and they expect that by 1960 the ten-year school will be universal. Enrollment in regular higher educational establishments training professionals of various types has grown six-fold. Training of supporting semi-professional personnel increased more than seven-fold. All of this expansion, of course, took place under rational calculations to satisfy the needs of the state and its expanding economy and power. Frequent utterances bear out this fact.

The purpose of higher education is expressed in the Soviet encyclopedia as follows: "To prepare highly qualified politically trained engineering personnel with well rounded education, cultured, wholeheartedly devoted to the motherland and to the course of Lenin-Stalin, capable of completely mastering and using the newest accomplishments of advanced science and technology and of merging scientific theory with the practical work of building a Communist society."

That the emphasis is on the state and its needs is clear. In a recent publication in Russia the remark is made that "The nature of the state determines the aims and purposes of Russian education," and quotes a remark by Stalin that "Education is an instrument whose effect depends on who wields it."

A remark by the eminent physicist, Peter Kapitza, is of particular interest. Speaking in 1943 to the Praesidium of the Russian Academy of Sciences he said in commenting on the central emphasis on

science and technology in Soviet planning: "This is mainly conditioned by the special place allotted to science in our socialist country. Of course, it is well known and generally accepted in other countries, too, that science plays a great part in the development of culture and technology. It has been allotted the leading part in the development of our technology and economic life. Therefore, the organization of science in our country must be more systematic and conscious of its aims than it is in capitalistic countries where it is rather left to chance and has a spontaneous character. In our country the bonds between science and life must be closer and deeper."

Soviet education as an instrument of the state is also strongly supported by the state. About 14% of the annual budget is set aside for so-called cultural-educational expenditures, and although the share of educational expenditures as such is uncertain, the high degree of support is undoubtedly evident.

The Soviet educational system begins with kindergarten into which children enter at three. How universal kindergarten now is can not be determined, but it is believed to be fairly general at least in the major urban and industrial centers. In these schools the elements of reading are taught so that the child should be able to read upon entering the elementary school.

The elementary schools are of seven years duration and concentrate on the three R's with other types of activities in music, art, etc., after hours. Home work is heavy, being specified as increasing from 1½ hours per day in the second grade to 3½ hours in the seventh grade. During the seven-year school a pupil spends about 6.5 thousand hours in class instruction, which lasts each year for 33 weeks with six days of required attendance each week. About 32% of the seven-year curricula is devoted to arithmetic, algebra, geometry, the natural sciences, introductory physics and the elements of chemistry.

After elementary school the student may enter secondary school or a technical school known as a technikum. In the secondary schools, open generally to the better students and largely preparatory for higher education, emphasis is strongly on science and mathematics for all students. There are no electives and about 40% of the curriculum is devoted during the three years to these subjects for all students. These schools are in general large as a result of established policy so as to make it possible to have each subject taught by a competent teacher specializing in a particular field of study.

The secondary school is a matter of considerable concern in Russia. The Party Youth Organizations, the Comsomol, since the early 30's, foster and encourage high scholarship among students. The leader in a Soviet class must usually be a good student—not necessarily a football hero. Indoctrination into the Soviet way of life, of course, permeates this, as well as other levels of education.

Educational Statistics

Perhaps some general statistics may give a concept of the increase in the Russian educational effort during the last two and a half decades. While in 1926 the enrollment in primary and secondary schools was about 10 mililon out of a population of 147 million, or about 7%, in 1950 it was 33 million out of an estimated population of about 193 million, or about 17%. It should be borne in mind that this includes a ten-year education, not twelve, as in America. In the United States, in 1950, the enrollment in the primary and secondary schools was 30,470,000 out of a population of about 152,000,000, or 20%. Soviet upper-grade enrollment (Grades 8–10 of the ten-year school) during the last five years increased fourfold and in 1953–54 was about 4.6 million, which is only about one-third smaller than our four-year high school enrollment. This increase has taken place while our own upper-grade enrollment has been experiencing the results of a low birthrate in the 30's. Graduations this summer

were about 760 thousands, as compared with virtually none in the middle 30's. It should be remembered that these graduates were required to have rigorous preparation in the sciences, while perhaps only 20% of our graduates had general science courses and only 6% to 8% had any physics and chemistry.

In higher education in Russia the enrollment in 1951–52 was 916,000, a 50% increase over the enrollment of 620,000 in 1939–40. In the United States the enrollment was 2,100,000, a 55% increase over the enrollment of 1,364,000 in 1939. However, it must be borne in mind here that a large percentage of American college students are not in training as specialists but are in college for a general education without fixed vocational goals. This is especially true of women.

Those who do not enter the secondary school may enter the technical schools or technikums. These are three or four year schools of a highly practical type intended to train technicians in a variety of subjects, including engineering, agriculture, medicine, law and pedagogy. The products of these schools are what may be called semi-professional and are an important factor in the Soviet economy. These trained semi-professionals represent the core of the Soviet supporting and intermediate level technical personnel, which in America we must supply through our technical institutes, junior colleges, and even through the regular four-year colleges as well. Their training, while short of professional training, is probably beyond that of technical institutes in the United States. The courses are about 40% theoretical, and in engineering include mathematics through the calculus. In engineering alone these schools probably graduate over 50,000 technicians per year. Since a part of their training has been on the job in industry they are prepared to enter at once into the industrial labor force. While technikum students are trained directly for work at the technician level and do not have much prospect of aspiring to higher levels, the door is not closed entirely in that about five per cent are selected because of superior accomplishment and promise for further study at the universities. There were in Russia 3543 technikums in 1952 with enrollments of about 1,000,000 students. Graduates numbered about 350,000 per year. Of these about ⅐ are engineering technicians indicating the figure of about 50,000 used above.

Some idea of the level of work accomplishment expected of the secondary school graduates as a basis for university entrance can be inferred from the entrance examinations. These include besides Russian language, literature and history, up to three languages, mathematics, physics, and chemistry. The mathematics examination includes the usual algebra and geometry, but in addition some complex number theory, theory of equations, progressions, logarithms, and the binomial theorem (trigonometry is included); chemistry includes some organic chemistry.

Very Progmatic Development

Higher education in Russia has had, because of its origin and because of the practical goals of the government, a very pragmatic development. There is little of the American notion of liberal arts education, education for cultural values or education to develop the capacity for valid value judgments. On the contrary, emphasis has been spent on the training of specialists even in the fields of linguistics, social sciences or humanities. The emphasis on science and the practical arts has been heavy.

Higher educational institutions in Russia fall into three classes. There are the traditional universities which to a large extent reflect the European pattern and are even yet strongly influenced by the heritage of Russian scholarship from prerevolution years. These are not many in number. They do, however, supply a large part of the flow of scientists who go into research in all types of laboratories and of the teachers in the secondary

schools and universities, as well as in other types of schools.

Those of the second type are the specialized higher educational establishments which were originated in the late 20's and early 30's by the ministries with technical responsibilities. They have since been placed under the aegis of the ministry of education but retain their special relationship to a particular area of technology represented by the ministry under which they were organized. It is in these institutions that the large majority of the engineers are trained. The curricula in these institutions are built around the industrial field of application rather than around the traditional subject matter divisions. These are communications engineers, mining engineers, agricultural engineers, construction engineers, transportation engineers, etc., rather than electrical, mechanical or civil engineers, as in our system.

Engineering training lasts five to five and a half years, and is based on about 5,000 hours of lectures, classroom and laboratory instruction, attendance at which is mandatory. An engineering student spends about 65% of his time on general sciences and general engineering subjects; about 28% of his time is devoted to narrow specialization and only about 7% to what are called socio-economic studies, which are mostly political indoctrination subjects. The training is supplemented with periods of practical work in industry. This narrow specialization on top of some basic engineering training is responsible for the break-up of traditional divisions.

In 1939 in Russia there were about 750 higher educational establishments which rose to about 900 in 1951–52, a 20% increase. This would not correspond to our 1700 institutions of higher education because of the large number of junior colleges and other types of institutions which would not figure largely in the training of specialists. Probably the number of American institutions in this field with 4-year courses and substantial specialization along professional lines would not greatly differ from the 900—more or less.

In the matter of numbers of graduates, the history of the Russian effort indicates the changing emphasis on numbers and quality. While the number of graduates in all fields in the late 20's was as many as 30,000 per year, the quality of instruction and the solidity of the training left much to be desired. Consequently, in 1930 and the following years, a drastic shakeup in higher educational institutions occurred which tightened standards and resulted in a temporary setback to the expansion of training. At the same time, however, there is evidence of much more attention to the selection of qualified faculties and effective instruction, as well as a rise in numbers graduating until by 1940 over 100,000 graduates, with almost 30,000 engineers, were emerging from training. The war greatly reduced the numbers in training and graduating, although this resulted more from the destruction of institutions by the German invasion than by policies of the government with regard to exemption of students. After the war there was an immediate national effort to rebuild the destroyed higher educational establishments, particularly in the Ukraine. By 1947, 156 of the 162 higher educational establishments in the Ukraine were again functioning. The remaining six were so completely demolished as to require complete replacement. In 1944 only 2200 students graduated from the higher educational establishments of the Ukraine, but by 1946 this number had risen to 15,200, in all fields.

The number of graduates in the sciences is difficult to judge because of the differences in specialization and reporting. In engineering, however, the record is clearer. After the war the numbers of engineering graduates rapidly increased to about 29,000 from all Russian schools in 1948, to 30,000 or more in 1951, to probably about 40,000 in 1953, and to over 50,000 in 1954, according to late indications. This may be compared to about 19,000 from engineering curricula, unaccredited as well as accredited, in American colleges and universities in 1954. It seems probable that the

total number of trained engineers in Russia today is closely comparable to the number in the United States.

In the field of the sciences, advanced work is to a large extent done in the many establishments of the Russian Academy of Sciences which is a major factor in Russian science. There are two advanced levels of recognition neither of which is directly comparable with the American system of degrees. The first of these is that of "Aspirant" or "Kandidat" and is given after approximately three years of study and research. While this level of accomplishment may approximate the doctorate in some fields, in others it may be more nearly the level of the master's degree. It seems probable, however, that in general, and especially in applied sciences and engineering, it should be rated well above the master's degree if not in all cases equivalent to a doctorate. In 1952 there were about 5500 "Kandidat" degrees granted, not substantially different from our own rate of production of doctorates.

The second level of recognition is the degree of doctor of sciences. This degree is granted only after many years of research and substantial recognition by scientific colleagues. In 1951 there were about 531 such degrees granted.

Summary

In summary, it seems possible to conclude that the whole effort in science and technology is a serious one, with full support by the government, which is realistically conscious of the vital role of science and technology in the furtherance of Russian aspirations, be they economic, military or political. There is evidence of substantial accomplishment, to the degree that Russian technology must be taken very seriously.

One further item may be mentioned. Prior to the recent war, military service was obligatory and the duration of individual responsibility was two years. Up to the end of the Stalingrad episode in 1943 students were called into military service. However, in 1943 a law was passed which had the effect of returning many to the universities and retaining students in their courses of training. According to this law, students in about 80 schools of technology were exempted from military service until graduation. Thereafter they were assigned for a period to specified posts in their specialties. As far as can be determined, this law is still in operation.

Thus Russia has apparently solved the vexing problem of the role of the technical specialist in a very direct manner, and in line with its realistic policy of considering scientific and technical personnel as merely another factor, but a most important one, in the total national military potential.

We do not have to make an attempt to abandon our principles of liberal and broad general education, but this should not prevent us from realizing the challenge which we face. Improving the teaching of science at the high school level; expanding the training of scientists and engineers; and the adoption of a consistent policy for the preservation of professional manpower, especially engineering and scientific personnel—all these are measures which are long overdue.

A Community Project in Professional Development[1]

By CORNELIUS WANDMACHER

Chairman, Professional Training Committee, Engineers' Council for Professional Development

The Challenge

One of the greatest challenges facing the engineering profession today is the professional development of young engineers in the first few years after graduation from college.

It is in this critical period that the young man is shaping his goals and establishing a pattern of personal development which will either lead him on to full professional maturity, or will leave him content to serve for years in mediocre, routine technical assignments.

It is in this period that the young man on his own initiative either learns to build upon the foundation established by his educational opportunities or he ceases to grow, falling into a post-college slump and drifting away from the profession for which he has prepared.

This is not a new problem; it has been recognized for many years. But it is a matter of greater concern as the demands increase for higher and higher standards of performance in the engineering profession.

Quantity vs. Quality

That there will always be a shortage of top-flight personnel is a generally accepted fact. At the same time it is pertinent to note that such shortages have qualitative as well as quantitative aspects. In fact, the demands on the side of quality are usually the ones more difficult to meet.

In the words of the National Manpower Council, as stated in its suggested "Policy for Scientific and Professional Manpower":

"Two second-rate engineers are not a substitute for the one first-rate man required."

The problem is not solely to interest a greater number of young men in the profession of engineering, but even to a greater extent to do a more thorough job with those already at hand.

The task of carrying the level of professional competence to new heights can be met in part by adjustments in curriculum and teaching methods, but also in large measure by a concerted effort in post-collegiate development.

Many of the demands made upon educational institutions to prepare the student in various fields of specialization or to round him out in one or another quarter could be met squarely by a sound program of continuing personal growth after graduation.

A Planned Program

The Professional Training Committee of ECPD has formulated such a program which relates to the "First Five Years of Professional Development" and establishes six essential points of endeavor. These are:

1. Orientation and Training in Industry
2. Continued Education

[1] Based on recent experience in the implementation of the 1950 "First Five Years" report of ECPD. Presented at the ASEE Annual Meeting, Urbana, Illinois.

3. Integration into the Community
4. Professional Identification
5. Self Appraisal
6. Selected Reading

Whose Responsibility?

The basic concept under which the six-point program has been established recognizes a responsibility on the part of the profession and also on the part of the individual. These guiding principles have been stated as follows:

a) Industry [2] and the enginering profession must provide the young engineer with a favorable climate in which to grow.

b) The young engineer must realize that the final responsibility for professional advancement rests with him, the individual.

Contributing Factors

Three factors in the life of the community and in the life of the individual affect his personal growth. These are: industry, the engineering societies, and the college or university.

Each makes its distinctive contribution to the development of the young man. Too frequently it is thought that one leaves off where the other begins. Actually, all three must continue to contribute to his growth for many years after graduation. For optimum growth, it is essential that there be close cooperation amongst these three agencies to insure maximum effectiveness.

A Concerted Effort

Engineers are realizing to a greater extent every day that the well-known geometric axiom that "the whole is equal to the sum of its parts," which is applied so frequently in technical matters, is not nearly so restrictive when applied to matters controlled largely by the forces of human relations.

In the area of human affairs, the accomplishments of several groups working closely together on a common problem, with well developed lines of communication, will be of far greater significance than the results of several separate efforts. In other words, the "whole" result of a concerted, cooperative effort can be *greater than* the mere sum of isolated, independent parts.

This is an important principle in two respects. In a community situation it means that there should be close and direct cooperation involving industry, the engineering societies, and the Universities, all working together in any professional development project. For the individual, it means that he should use the opportunities for continued growth offered by all of these three agencies. To neglect any one is to lose the advantage of interrelated stimulation.

Cincinnati—A Pilot Study

For the last two years a pilot-study of the ECPD professional development program has been underway in Cincinnati, Ohio.

The purpose of the pilot operation has been to study how well the six-point program meets the needs of young men in a typical industrial community and what mechanisms of operation are best suited to achieving the objectives of the program.

This study has been carried out through the co-operative effort of a Local Industry Committee, the University of Cincinnati, and the professional development committees of the Engineering Society of Cincinnati with which the local sections of the various participating societies of ECPD are associated.

Community Experience

Experience in Cincinnati has confirmed that "The First Five Years of Professional Development" is a well-conceived program of real merit and of great potential assistance to the young engineer. There are many obvious advantages of a

[2] The term "industry" as used in this report refers to the broad field of professional practice including engineering activities in consulting and civil service, as well as the manufacturing, public utility and construction industries.

well-rounded, package-type of program. A number of suggestions have been made for modification and amplification of the program but the basic framework is clearly sound.

A summary of some of the activities and comments relating to the program may best be made by referring to the six points.

1. Orientation and Training in Industry

Industry's Essential Need

The most important essential of industry is a loyal, efficient, aggressive working organization. Andrew Carnegie once said that if his factories and money were taken from him, but if he were left with his men, he could again rise to his position of leadership in industry.

The most difficult task of management is, as stated in the policies of one of the industries participating in the Cincinnati area project:

"To find the man who has the particular characteristics and experience needed for each place to be filled, and then to take the total number of men so employed and develop them into a trained, unified, efficient and loyal 'team,' satisfied with their opportunities and happy in their relationships with the Company." [3]

What the Young Man Expects

A well-planned orientation and training program will help the young man make the transition to a full-time productive job in industry and at the same time give him the specific knowledge he needs to move forward in the organization which he has selected for his initial employment.

There are two things which young men inevitably expect from an employer: (a) encouragement, (b) recognition. Some companies do much better than others in giving their employees deserved opportunities and proper advancement.

Inadequate personnel development leads to good jobs being filled from the outside rather than by promotion from within the company. Such incidents stifle initiative at lower levels. Good management is self-propagation.

For Companies Large and Small

Small companies need a personnel program as much as large companies, but it must be designed especially to suit their needs at a particular time.

Flexibility in scheduling and a greater air of informality would characterize the program for a small company, to a greater degree. Nevertheless there should be a definite plan and a check-point system for follow-through.

Recent investigations in Cincinnati indicate that most of the larger companies now have a formal orientation and training program. The greatest need for further development of such programs appears in the small and medium-sized companies.

The Cincinnati Industry Committee is currently preparing a check-list type of report which will present a basic framework from which the minimum essentials of a sound program may be chosen by any company.

Individual Initiative

Whether or not there is a definite training program in his company, there is much that the young engineer should do on his own initiative. Being alert and inquisitive; looking over available reports, plans, and literature relating to company activities; learning all he can about other areas of work in his department; with supervisory approval visiting various other sections of a plant or project—all can yield valuable background information and contribute to his self development.

2. Continued Education

To Stop is to Fall Behind

One of the marks of a professional man is his continuing interest in education as a medium of personal growth. The truly professional man recognizes the march of

[3] Armco Policies—adopted originally December 1919.

progress which is constantly occurring and also knows that if he ceases to advance with the group he will in effect be lagging behind. He knows also that the principal purpose of his college education was to establish a firm foundation on which he could continue to build throughout his lifetime.

The most difficult problem facing the young man is to recognize the point at which he must undertake full responsibility for the continuation of his personal growth. During the years on the college campus he has been working steadily in a planned program, a curriculum laid out for him and prescribed by the faculty. Upon graduation he becomes his own educational director.

The Importance of a Goal

During the years in college the student engineer has been working toward a well-defined, specific objective, his degree. After graduation he may seek an advanced degree, or he may simply seek to deepen or to broaden his education in certain fields as may best pertain to the line of endeavor which he chooses for his life's work.

In either case, the young engineer must learn that education is a journey—not a destination. He must come to know how important a carefully planned educational program can be in keeping him mentally alert and in providing the stimulus for continuing personal growth. He must establish his own professional objective and work each year steadily toward that goal.

Experience has demonstrated that unless the young engineer formulates such a plan soon after he leaves college, he is not likely ever to do so. The core of his plan should be to relate the basic principles of science and of the humanities to his experience in technical matters and to his associations with people.

Growth in Part-Time Graduate Study

While it is not the intent to convey the impression that part-time graduate study is the most important aspect of the "Continued Education" program, it is a point on which a great deal of definite progress has been made in the last five years.

A survey in 1948–49 which inquired into the opportunities available in 50 of the principal industrial communities of the country indicated that none existed in over 70% of the areas investigated.

A similar survey now being completed indicates that only about 20% of the major industrial areas of the country are now without any opportunities for part-time graduate study on the part of the young practising engineer.

Results of a Concerted Effort

The program established only last year at the University of Cincinnati was sponsored in the main by a group of industries which had been brought together by the stimulus of the ECPD Community Project. While the plan had been under consideration by the University for some time, it was the concerted effort of the Local Industry Committee, the engineering societies and the University which brought it to a state of reality, with an enrollment of nearly 300 students in its first year.

In this instance, ten industries supported the publishing of a special announcement of the graduate engineering program and actually promoted the program in their own organizations through top management channels.

A Need for Short Courses and Seminars

In addition to the demand for credit courses at the graduate level there is also an ever increasing need for short courses and seminars of the non-credit type. These mediums represent probably the best way to introduce the young engineer to advanced topics in his specialized field and to help him keep abreast of new developments in engineering practice.

Such short courses may be sponsored on a company or industry-wide basis, by engineering society groups, or by special sessions on the University campus.

A Broad Gauge Program

Some of the more broadening outlets for continued education are found in lecture series and forums.

One of the more successful projects of this type in Cincinnati is the Business and Professional Men's Lecture Series, which presents outstanding speakers in the fields of economics, government, literature, world events, journalism, and sports. Nearly 20% of the registrants in this program during the past several years have been engineers.

3. Integration into the Community

A planned activity for introducing the young engineer into the community in which he begins his career and professional practice divides itself into two parts:

a) Aiding the young man in developing a sense of belonging in his new environment, and
b) Pointing out to him the civic and professional responsibilities which he should assume.

Developing a Sense of Belonging

Each newcomer wants to feel a sense of participation in the group activities of which he becomes a part. Young people are eager to participate in community affairs and yet are extremely hesitant to introduce themselves into the life of a community which seems sufficient and complete without them. Community groups must, therefore, feel a responsibility to make the initial contacts with new young people.

The professional activities committee of ESC each year arranges a Newcomer's Night for welcoming all men who have recently arrived in the community. Names of newcomers are furnished by the industries. The letter of invitation to attend this special program includes data on activities of all 24 participating societies of the Technical and Scientific Societies Council of Cincinnati.

Newcomers' Guide

During the past year an ESC committee has been preparing a community orientation booklet for new engineers arriving in the Cincinnati area. The six chapters include:

1. Professional Activities
2. Educational Opportunities
3. Civic Information
4. Cultural Activities
5. Recreational Facilities
6. Religious Activities

It is planned to distribute such a booklet to newcomers this year through the cooperation of industry.

Civic Participation

The community has a definite interest in drawing professional people into its activities. Engineers, particularly, can contribute not only sound judgment for the solution of civic problems but special knowledge applicable to city planning, construction and public services.

Engineers are frequently critical of the shortcomings of solutions to community problems; but not always have these same engineers done anything about these problems themselves. The additional education and training, beyond the average, which engineering graduates have enjoyed places upon them an obligation to use the benefits of such education in the public interest.

As long as any engineer limits his attention to his job alone, he will remain a technician. Only as he develops an interest in servicing society through his community as well as through his job will he begin to discharge the responsibilities of the professional man he seeks to become.

The ESC Committee on Public Affairs has in the past year been active in and kept the membership informed on matters relating to expressways and turnpikes, fluoridation of the city water supply, and choice of a new City Manager. An active member of ASCE was recently appointed to the post.

Public Affairs Manual

An excellent reference on this topic, which has recently been brought to the attention of the committee, is the ASME Manual, MS–61, "Citizenship and Participation in Public Affairs" which includes the Engineers Manifesto on Civic Responsibilities, prepared by Herbert Hoover, and reprints of the Roy V. Wright Lectures.

4. Professional Identification

In the original statement of the six point program, this section was headed "Professional Registration."

Discussion in Cincinnati and elsewhere indicates that this point probably should be established on a broader basis. This new approach recognizes the importance to the young engineer of taking "two steps" at graduation.

Two Steps

Two items of equal importance are essential to being identified as a professional man:

1. To become actively associated with an engineering group such as a national or local society.
2. To qualify for professional registration.

Society Membership

The several plans for "graduation" from student chapter membership to regular society membership have generally worked well in the first year after college but some societies report a large drop in young men after the first year.

Most engineering societies do recognize how necessary it is to provide an adequate program at the local level for young engineers. Few young men have an opportunity to attend national meetings. The only personal contact which they have with their societies, therefore, is through the local section program. More and more such local programs are being directed toward the young men only a few years out of college.

Getting Acquainted

Moreover, young men usually expect senior members of the societies to make the first overtures in striking up an acquaintanceship. This fact should be taken into account in planning any program to stimulate participation of young engineers.

Along these lines the Cincinnati section of AIEE has successfully conducted an annual "Father and Son" dinner, in order to better establish personal acquaintances between the young recruits and the senior members of the section.

Professional Registration

The work of encouraging professional registration of the graduate engineer is now well in hand. In some states approximately 75% of the graduating students currently take engineer-in-training examinations.

This EIT movement which stimulates the senior-year student to take the examinations immediately upon or before graduation regardless of where he intends to practice, has been greatly advanced by two factors:

a. The excellent opportunities which exist for the transfer of this credit by reciprocity in other states.

b. The general policy which permits the use of EIT examination credit toward the written examination requirements for full licensing.

While advancement in his career is entirely dependent upon the young engineer's technical and other abilities and how he applies them in his work, these two steps of professional identification contribute much to his self-development and professional stature.

5. Self Appraisal

Success depends in a large measure on working in a field for which one is well suited by virtue of education, aptitudes, and interests. The better the young engineer understands the requirements of the different types of work and the better he understands himself the easier it is

for him to relate his objectives to his abilities.

It is impossible to overemphasize the fact that technical competence is the *necessary* but not the *sufficient* condition for becoming a professional engineer. There must be developed, in addition, certain qualities of personality and of character which will establish unmistakably a feeling of trust, confidence, and loyalty in man-to-man relationships.

6. Selected Reading

On this point much assistance to organized engineering groups desiring to stimulate good reading will be forthcoming from the various public library systems which are currently faced with the competition of other recreational media. Engineers in most communities could well afford to become better acquainted with the diverse library facilities available to them.

The Cincinnati and Hamilton County Library has furnished the ESC headquarters with a loan collection of 80 books from the Reading List for Engineers. Synopses of these books have been written by the library committee and published serially in the *Engineer and Scientist,* a weekly bulletin which is circulated to all Society members in the city.

A Threefold Reading Program

Discussions of reading habits have brought out the fact that any reading program should include three essential parts:

a. General readings in biography, travel, history, economics, sociology, psychology, philosophy, natural science and literature, including fiction and essays.

b. Technical readings as represented by books listed in the various sections of the ECPD Selected Bibliography of Engineering Subjects.

c. Professional reading such as that made available by the periodicals of the National Societies and industry.

Reading List for Engineers

Some 300 junior engineers are cooperating in a review of the ECPD Reading List for Engineers, to ascertain the adequacy of the current edition. A revision of the list based on the evaluation by these young men will be considered during the next year.

Several sections of the Selected Bibliography of Engineering Subjects are currently being revised.

Implementation

As now conceived the plans for implementation of the "First Five Years" program require simultaneous promotion along three lines:

1) Providing an introduction to the program for students before graduation,
2) Stimulation of a better understanding of the program in the respective national committee of the participating societies of ECPD,
3) Development of a number of community projects with the aid of industry in selected industrial areas.

Before Graduation

During the past year the Training Committee has taken a number of definite steps toward the introduction of the "First Five Years" program to senior engineering students before graduation from college.

It is now generally recognized that the avoidance of the "post-college slump" is not entirely a post-college task. The ideal time to begin to talk with young engineers about a program for professional development after graduation is while they are still members of a more or less homogeneous group on the college campus.

Use of "First Five Years" Brochure

Thirteen colleges having professional development programs for seniors participated this year in a trial use and distribution of the "First Five Years" brochure. Schools emphasizing the ECPD six-point professional training program in cooperation with the committee this year included:

Alfred University
University of Akron
Carnegie Institute of Technology
Case Institute of Technology
University of Cincinnati
University of Detroit
Fenn College
University of Nebraska
Newark College of Engineering
Ohio Northern University
Ohio University
University of Tennessee
Wayne University

While many colleges have professional development programs of various patterns, some of them running from freshman through senior years, the objective of this committee is to introduce the graduating student to a well-rounded, unified program such as the six-point program. Indications are that this may best be done in the final semester, just prior to graduation.

Revision of the "Professional Guide"

As the six-point program for the "First Five Years" becomes more fully crystallized, it appears desirable to have a statement of this program as an appendix in the "Professional Guide for Junior Engineers."

The current supply of the "Guide" is now almost exhausted. In a number of years of usage of this manual, only a few suggestions for revision have been received, some of which will be incorporated in a new printing. It is the opinion of the ECPD committee that the original chapters by the late Dr. William E. Wickenden should be preserved in the "Guide" but that steps should be taken to incorporate the statement of the "First Five Years" program at the earliest possible date.

Copies of the "Professional Guide for Junior Engineers" are widely used by colleges and universities and are regularly circulated to all young members of EIC and AIME.

Young Engineering Teachers

ECPD has a special stake in the Young Enginering Teachers of ASEE. This group is composed predominantly of men who are currently interested in their own personal professional development. At the same time they represent one of the greatest potential sources of inspiration to students in the "before-graduation" aspect of the "First Five Years" program.

Many of the YET groups this year gave attention to the discussion of the six-point program and a vigorous promotion of professional guidance programs has been declared one of the main objectives of the committee.

Promotional Aids

For the assistance of groups interested in the development of local projects the Training Committee has prepared two brochures, a set of display posters, a 35 mm slide series, and condensations of the various sections of the 1950 report suitable for serial publication in society magazines and bulletins.

Conclusion

It is the conclusion of this study that many of the demands now made upon educational institutions to prepare the student in various fields of specialization, or to round him out in one or another quarter, will be met in the future by expanding programs for continuing personal growth after graduation.

In these programs, for which the six-point plan of the "First Five Years" provides an excellent base, industry and the engineering societies will take an increasing responsibility in co-operation with the colleges and universities of the community in which the young engineer begins his professional practice.

At the same time it is expected that further steps will be taken to introduce the "First Five Years" program to students on the campuses of engineering colleges "before graduation."

The Role of Physics in Engineering Education*

By N. H. FRANK

Head, Department of Physics, Massachusetts Institute of Technology

The problem of reassessing the role of physics in engineering education has come to be a matter of considerable urgency and significance primarily because of the rapidly changing character and expanding scope of both engineering and physics. This assessment must be made not only in the light of these facts, but also in terms of the requirement of establishing objectives such that, as far as one can forsee, the continuing evolution of both physics and engineering will not render them prematurely obsolete. In general, both physics and engineering are confronted with the same fundamental problem, viz., that of inculcating into the student a more difficult expanding body of knowledge, with an increasingly subtle and complex theoretical base, and essentially no more time available in which to teach it. Any projected plan of coping successfully with this challenging problem must be viewed in the light of the changing pattern of requirements in both engineering and physics education. Let me start then by discussing briefly the salient points in these areas.

The Changing Pattern of Engineering Educational Requirements

Of utmost significance to our considerations is the relatively recent shift of the technical base of engineering from one that is largely empirical to one which is preponderantly scientific. This change clearly throws the spotlight on the basic sciences, especially on physics, and depicts them as playing a critical role in engineering education. There has also come into being a greatly augumented need for a deep and fundamental insight into a multiplicity of disciplines over and above the more traditional engineering subjects, such as the humanities, social sciences, management, physical sciences, etc., and also of providing opportunity to the student for gaining experience in synthesizing broad solutions to complex operational problems. There is a rapidly growing emphasis on the integrated character of engineering problems—as examples, I might cite the broad areas of transportation and of the conversion and distribution of power.

Not only are the number of pertinent disciplines growing, but the requirements for depth of comprehension are sharply enhanced, and this is particularly true with respect to physics. The need for more modern physics, exemplified by solid state and nuclear physics, is well attested to by the recent recommendations and programs drawn up by committees of this society. The pressure for skillful and effective inclusion of these subjects into engineering curricula is real and great, and stems in no small measure from the unprecented speed with which discoveries in pure science are translated into practical application.

May I suggest that because of the foregoing there is urgent need for far-reaching changes in the character of engineering science subjects. Much of the purely factual information and many of the items relating to current practice traditionally included in such subjects should be eradicated to make room for more urgent needs

* This article is the text of an address given by the author at the annual meeting of the American Society for Engineering Education at Urbana, Illinois, June 15, 1954.

The Changing Pattern of Physics Educational Requirements

Not only have the requirements of engineering education changed markedly, but the same is true to at least as great an extent in physics education itself. Twentieth century physics has provided us with probably as much progress in the understanding of natural phenomena as had been attained in the whole previous history of mankind. The significance of this progress is by no means confined to the simple gathering of large amounts of new factual matter, but there has come into being an abstract and complex modern theoretical physics—I refer to quantum theory and relativity—which are no longer pure intellectual pastimes for the few, but are essential for modern engineering as well as for physics. The increase both in the complexity and scope of physics calls for the excision of much of the traditional subject matter of physics courses and for the introduction of the modern spirit and the inclusion of examples from modern physics to illustrate fundamental principles at *all* levels of instruction. This is by no means an easy task, especially for those of us who have been brought up in the tradition of the older physics. We are loath to keep from the students many of the classical applications which have served us so well in the past and which are as valid and useful today as they ever were. But a choice must be made, and I believe that we must look upon this sacrifice as a necessary one, analogous to foregoing a luxury, no matter how pleasant, in the face of more urgent needs.

With this brief resume of the more pertinent present day educational requirements in physics and engineering as a background, I now turn to the task of attempting to formulate the objectives of physics in engineering education. As a consequence of my earlier remarks, it seems evident that physics must play a dual role in engineering education. First, physics plays the role of one of the great humanities, and as such it follows that physics should be taught as a pure science. I feel that physics, along with mathematics, represents one of the greatest intellectual achievements of mankind, and the impact of the growth of science on social and political ideas has been such that a proper understanding of our present day culture and problems is difficult to attain without an adequate scientific background. This role of physics as a humanity fits in admirably with the growing emphasis on humanities in all engineering curricula.

Secondly, there is the more traditional role of physics as a technical base for engineering science subjects. In the past this has been almost exclusively the reason for the existence of physics in engineering curricula and as such the teaching of physics more often than not assumed the form of introductory engineering. I need hardly remind you that such limited objectives for physics are no longer adequate. Keeping in mind this duality of purpose of physics for engineers, I should like to propose the following tentative statement as encompassing the broad objective of physics in engineering curriculum: THE OBJECTIVES OF PHYSICS COURSES IN ENGINEERING CURRICULA ARE FIRST, TO GIVE THE STUDENT A BROAD AND COMPREHENSIVE BACKGROUND IN PHYSICS AS A CULTURAL SUBJECT, AND SECONDLY, TO SUPPLY A DEEP QUANTITATIVE SCIENTIFIC BASE ON WHICH A MAN MAY BUILD HIS ENGINEERING CAREER WITHOUT SIGNIFICANT LIMITATIONS OF FLEXIBILITY OR DEPTH OF PENETRATION IN A GIVEN AREA.

If this is a sound statement, then it becomes clear that there must be great emphasis on *pure* physics in the physics course for engineers. Applied physics should be taught largely by engineers as an integral part of engineering science subjects. At this point I feel it necessary to refer briefly to proposals which have been made which would take over by engineers the teaching of all classical physics and delegate to physics departments the

limited task of teaching modern physics. To my way of thinking—and I am sure that physicists as a whole will agree—any such course of action would not only be bad but practically fatal. Physics is a tightly integrated and coherent subject in spite of its wide ramifications and cannot be dismembered into classical and modern physics without destroying the very benefits which one aims to derive from physics education. Modern physics and its principles have evolved as generalizations from classical physics, and it is virtually impossible to impart a solid quantitative understanding of modern physics without a sound classical base as taught by physicists.

Cooperative Planning by Engineers and Physicists Needed

I submit that there is a firm requirement for active cooperative planning by engineers and physicists to create mutually supporting subjects with well defined objectives. Let me illustrate briefly with a few examples of the sort of changes which might well be made as a result of such an effort. In mechanics the physicist should have as his primary objective the teaching of the basic laws, with great emphasis on the broad conservation principles (momentum, angular momentum, energy). The latter, rather than Newton's laws themselves, have provided the springboard for the evolution of quantum theory and relativity. An introduction to as much of modern physics as relates to mechanics should also be undertaken and the examples used to illustrate the principles should be drawn to a large extent from present day physics. I see no reason, for example, why electric and magnetic forces should not be introduced in the beginning mechanics course, even though traditionally they have been excluded. The engineering mechanics should then take over in its entirety the subject of statics, essentially all of the study of constrained motion, and much of fluid dynamics, acoustics, and similar topics. In electromagnetism the physicist should be concerned with the exposition of field theory and microscopic electrodynamics, whereas the engineer should teach circuit theory and large-scale, macroscopic electrodynamic theory. In thermodynamics I would suggest that the physics course be concerned primarily with kinetic theory and the statistical approach to the subject, whereas engineering thermodynamics could dwell on the applications and exposition of classical thermodynamic theory. I could go on at length with further examples, but I hope this will suffice to illustrate the sort of changes which I envisage. I cannot resist the temptation at this point of making a few remarks about the long-standing controversy with regard to the systems of units employed in engineering and in physics. I myself cannot get excited about these matters, since I believe a student can learn more than one system, but it seems to me that the differences of opinion that have existed in the past will gradually disappear, since the introduction of modern physics into engineering will call for a revision of engineering units to conform more to those employed in physics. For example, I have long been amused by the controversies about mass and weight and the insistence of some engineers on talking at length about local and standard values of the acceleration of gravity. The concept of mass as used in present day physics is a far cry from the primitive notion of quantity of matter. I refer to the concept of mass in the theory of relativity, or to the effective mass of an electron in a solid. These concepts are hardly dependent on the gravitational field of the earth, so perhaps we have finally reached a point where this controversy will disappear.

Now, all that I have been proposing would be of little import if it were not supplemented by an additional and crucial requirement relating to the intellectual level of the courses which are involved. There is a stringent requirement for a quantitative, intellectually challenging treatment of physics, and there can be no

place for so-called survey courses at any level of instruction. The abstractness and the indirect methods of attack which characterize modern physics must be faced squarely, and not circumvented. Turning our backs to the difficulties which arise from these factors will in no way help solve the problems which confront us. This intellectual requirement is a "*must*," independent of the student body. I realize that in many schools the relative limitations of background of engineering students will create major difficulties, but, as I have already said, nothing can be gained by avoiding the challenge.

In talking about the quantitative treatment of physics, I should point out that there is always a risk that physics and engineering science might turn into applied mathematics because of our enthusiasm for advanced quantitative methods. This, of course, is to be avoided. There is an urgent need for developing interest and skill on the part of the students in the methods of probing into new areas in which our understanding is either lacking or incomplete. Here much is to be learned from the history of physics. We must concern ourselves with the development of intuition and judgment; for the feeling for orders of magnitude of physical quantities; and for the pertinent as contrasted with irrelevant or minor factors in complex problems. In charting a course which gives proper relative emphasis to rigid mathematical analysis on the one hand and to intuitive, qualitative thinking on the other, we face a truly difficult problem which can only be solved satisfactorily by the very scientific methods which we try to impart. There will be many satisfactory solutions to this problem, I am sure, and there will be variations depending on students, on subject matter, and not least of all on teachers. This problem constitutes the greatest single educational challenge for the future and requires for its solution great emphasis on laboratory instruction and proper attention to the experimental foundations of science.

Conclusion

In conclusion, may I plead not only for receptivity on the part of engineers to a new approach to our educational problem, but for an urgent and compelling demand by them for such a new approach. To implement successfully any significant changes, I must mention the role that textbooks play. In the last analysis, the only really effective means of communication of new ideas and patterns of education are provided by the textbooks used by the teachers throughout the country. I am sure that our friends in the publishing business stand ready to do all they can to help bring into being suitable textbooks of a new character which will help us in our endeavors. Of course, we must remember that the publishers have their problems too, and we certainly cannot except them to publish large numbers of books for which there is a negligible market.

Essential to the success of any effort in this domain is cooperative planning by both engineers and physicists, encompassing far reaching changes in our current educational pattern. This planning should aim at establishing a broad framework and broad objectives; the details and choice of paths leading to these goals must be left to individual schools and their faculties.

This, then, is my assessment of the real challenge to be met if engineering education is to meet adequately the requirements of our modern world and to foresee intelligently the expanding horizons of the future. In helping attain these ends, physics can and should play a most important role.

Employers, Ethics and Novice Engineers*

By CLEMENT J. FREUND

Dean, College of Engineering, University of Detroit

A dean of engineering earns his living by doing a number of things. One of these things is to listen patiently and sympathetically whenever an alumnus, especially a recent graduate, feels like weeping on his shoulder.

Not long ago such a one was in my office to tell me his troubles. His troubles were really not very serious. He was two years out of college. He had a good job in one of our Detroit automobile manufacturing corporations. As I remember it, he had something to do with the development and redesign of the combustion area above the pistons. He was making good progress as far as I could see. But he was restless and dissatisfied, and he thought that he ought to resign and look somewhere else.

This interview was a familiar experience. It seems that very many of our engineering graduates are unhappy and discontented.

A Comparison

I could not help comparing this recent graduate with a young physician of my acquaintance who is an interne in a hospital near my home.

The young physician studied eight years following high school; the young engineer four years.

The physician spent about $10,000 in tuition and fees—or his parents did; the engineer about $2500.

The physician has impossible working hours. He is on call day and night; the engineer works an easy forty hours per week.

The physician is married but lives at the hospital. He gets his meals there although he has an occasional day off. The engineer lives pleasantly with his wife and small son in a five room apartment.

The physician is paid $1200 per year, and his keep; the engineer was paid $4600 per year when he graduated, and he gets more than that now. The physician is contented with his rugged and meager assignment; the engineer is sitting on top of the world and is dissatisfied.

Obviously, the young interne has something which the engineer does not have. The engineer has an immense advantage over the interne in every respect except for that something. That something makes the young interne happy with his lot, while the engineer is clearly unhappy.

I know both young men very well. I have studied the attitudes and mode of life of each. I have just about made up my mind that I know the secret of the interne's peace of soul.

Professional Standing

The interne is a member of a great profession; he is proud of it and happy about it. The engineer may belong to a profession some day but he is not sure. Certainly he does not think much either of his profession or about it.

The interne is respected. He enjoys all the strictly professional privileges of the oldest surgeon on the staff. He has the title of doctor, and all in the hospital address him as doctor. He has authority

* Presented at the Relations with Industry Division, American Society for Engineering Education, University of Illinois, June 15, 1954.

over nurses, attendants and other employees, many of them twice his age.

Nobody in the hospital may openly question his medical judgment except senior physicians and surgeons. Patients do not know the difference between him and the younger men on the regular medical staff.

The engineer, on the other hand, is just another employee, no different from thousands of toolmakers, assembly men, payroll clerks, draftsmen and the like. He has authority over nobody. He is a college trained engineer but, except for personnel officials, nobody knows it and nobody cares.

Significance of Ethics

What has all this to do with engineering ethics? A great deal, it seems to me. Let me start this way. Many employers are worried about the Engineers and Scientists of America. This is the union, as most of you know, which is currently attempting to enroll employed engineers. Other unions have tried, and none have achieved more than an ambitious start. But the succession of failures is small consolation to nervous engineering employers; this union might succeed.

This brings us to the core of the whole argument. In my view, employers will have no union trouble if they recognize the professional character of their engineers.

Employers, of course, do recognize technical ability and competence in engineering. But technical ability and competence are not the sum total of professional standing. Professional standing is made up of two elements: technical competence and training, and high honor and integrity, or ethics.

Engineering employers, it seems to me, ought to be as much concerned about the ethical standards of engineers as they are concerned about technical education and ability.

When I say ethical standards, I mean the ethical codes of the engineering profession. I do not mean the special policies and regulations of the particular corporation in which the engineer is employed. I make this point because employers occasionally call an employee unethical merely because he has violated some regulation of the individual employer which pertains only to his business.

It would be interesting to gather here at Urbana all the seniors of the University of Illinois who were interviewed by employers this year. I suppose there are hundreds of such students. It would be interesting to inquire of this crowd of seniors if a single one of them was asked by any interviewer what he knows about the ECPD code of engineering ethics; or about the code of the American Society of Mechanical Engineers, the American Society of Civil Engineers, etc. Not a single hand would be raised in answer to your question.

When engineering employers habitually and regularly insist that engineers shall know their ethics, just as they insist that engineers shall be technically competent, they will have gone a long way toward giving engineers professional standing. Then, and not until then, will engineers enjoy the professional standing of physicians and lawyers in the employ of corporations.

Once the employer has given his engineers full professional standing, he can safely discard the countless rules and regulations of the familiar employees' handbook, as far as his engineers are concerned. If he explains to his engineers a few basic policies of his corporation, he can thereafter safely depend upon their honor and integrity as professional engineers.

Solution

The employer who does all this need not worry about the Engineers and Scientists of America, nor about any other engineering union. If he will give to engineers the personal privileges that go with professional status, he will have no

union problem in his engineering staff, and few personnel problems of any kind.

Unions do not try to organize clearly professional people when they are known to be professional. Did you ever hear of the AFL or the CIO trying to organize the physicians of the Mayo Clinic at Rochester? Did you ever hear of an AFL or CIO union competing in Chicago with the Cook County Bar Association? Did you ever hear of the American Federation of Methodist Ministers? Did you ever hear of some radical Italian union trying to organize the staff of cardinals and monsignori at the Vatican?

No Misunderstanding.

It is very easy for me to be misunderstood about an issue like this. It may be important for me to explain at this point, and to explain emphatically, that I am not opposed to labor unions in their proper function, and when they are decently and legally managed. But I am positively opposed to labor unions in medicine, in law, in the ministry and in professional engineering.

Conclusion

We engineering educators must face up to our responsibilities. There are two sides to this question of engineering ethics. If General Electric, the Bell Telephone System, Westinghouse, Allis-Chalmers, and all other engineering employers begin to look for young engineers who know their ethics, it is going to be up to us in the colleges to teach ethics.

In the past, we have taught them to be reasonably competent in technology; but we have told them precious little about engineering ethics.

I respectfully suggest that it is high time for us to mend our ways.

College Notes

Top national authorities in education and professional fields will participate in a series of 10 academic symposia scheduled during the Centennial Year of **Michigan State College** in 1955. The Centennial year will open officially Feb. 12 with Founders' Day featuring an address by James B. Conant, former president of Harvard University and now U. S. High Commissioner of Germany. Other highlight programs will be an October Convocation at which President Eisenhower is expected to speak, and a world's fair Centennial of Farm Mechanization in August featuring a century of farm equipment. The academic symposia will cover the fields of education, business, agriculture, home economics, engineering, science, the arts, communications and veterinary medicine.

Comments on Interim Report of Committee on Evaluation of Engineering Education

Industry Views the Interim Report

In cooperation with the ASEE Committee on Evaluation of Engineering Education, the General Electric Company has submitted the Interim Report to a number of leading industrial executives for their comments. The following is a summary of these comments. We received approximately 100 replies, about 60 from within G.E. and 40 from electric utility executives. There is almost unanimous agreement that the principles embodied in the Report represent a marked advance in engineering education.

The specific comments, which largely emphasize portions of the Report, are grouped into five broad areas and arranged approximately in the order of number of times mentioned.

A. General

1. The greatest shortcomings of the young engineer are inability to express himself and a deficiency in human relations understanding.

2. Corporations are in a better position than the colleges to teach engineering practice. One reason for this is that engineering methods change so rapidly that a specific technique taught in the schools is likely to be obsolete by the time the student is ready to put it into practice.

3. An engineering graduate should be educated, not merely trained. Since upon completion of his undergraduate training an engineer is merely beginning to learn, colleges should concentrate on providing the engineer with a broad base. This means, a fundamental understanding of basic sciences and a humanities training that is closely coupled with his engineering training.

4. Some writers feel that more should be done to develop the latent creative abilities of the students.

B. College Educational Methods

1. The similarity and analogies of the concepts of the basic engineering fields should be emphasized.

2. Greater differentiation should be made on the basis of ability and more opportunity should be provided for the gifted student to perform to the limit of his abilities. Here we are interested in the segment of the class which is capable of accelerated study.

3. More attention should be paid to reading and study habits. The student who is taught to read rapidly and comprehensively can double his productivity.

4. The methods of attack utilized in solving overall engineering problems should be emphasized.

5. Closer collaboration is needed between the Physics, Engineering, and Mathematics Departments. The studies of Mathematics and Engineering should be well coordinated so that the student studying Engineering can make full use of all the mathematical tools available.

6. Although engineering laboratory time can be reduced, we should be careful not to eliminate laboratories teaching basic experimental methods. Laboratories can be used as problem solving experiences and they permit practical application of the theories.

7. With the introduction of these proposed curriculum changes, motivation of

the student may become a problem since the student will receive less actual engineering education early in his college training.

8. Periodic rating of professors is desirable since a proper balance of technical competence as well as teaching ability appears to be necessary for effective teaching.

9. The cooperative system for training technical people offers great advantages to both the student and industry.

C. College Curriculum

1. The greatest controversy in this area centered on the four versus five year curriculum. A slight majority favored the four year program, feeling that further college training was not always necessary and that widespread adoption of the five year course would reduce the number of graduates available.

2. The student should be taught effective presentation, both oral and written. Inability to express himself is felt to be one of the most severe shortcomings of the engineering graduate. In this connection, an attempt should be made to integrate the study of English composition with technical report writing.

D. Changes in Pre-College Training

The following changes are recommended in order to provide the colleges with better qualified high school graduates and to insure that the right people enter the engineering profession.

1. More emphasis should be placed on counseling and guidance in the high schools. Aptitude and interest tests should be taken by all students and they should receive vocational counseling from qualified individuals.

2. Early attention should be paid to study and reading habits. A course in comprehensive reading should be made available to high school students as an elective subject.

3. In the high schools as in the colleges more opportunity should be presented for the interested student to perform to the limit of his ability. Most of our high school education is directed toward the middle or lower portion of the class thus discouraging the initiative and wasting the time of the more capable students.

PAUL J. HESS
Engineering Services Division
General Electric Company

Comments on Evaluation Report

Dr. Lynton E. Grinter, Dean
Department of Engineering
University of Florida
Gainesville, Florida

Dear Dr. Grinter:

Under date of August 2, 1954, Mr. Clarence H. Linder, Vice President of the General Electric Company, forwarded a copy of the "Interim Report of the Committee on Evaluation of Engineering Education" to Mr. H. J. Cadwell, President of the Western Massachusetts Electric Company. In the letter of transmittal which accompanied the report Mr. Linder suggested that the committee would probably welcome comments on this report and that said comments should be addressed to you. Mr. Cadwell has referred Mr. Linder's letter and the report to me for study and comments.

I wish to congratulate the committee on the completion of a very excellent report. It is evident that a great deal of work has been done on this general question and I think that the report represents a very definite contribution to the solution of a difficult problem.

We are in full agreement with the objectives of engineering education as outlined in the report. We approve the placing of emphasis in undergraduate work upon fundamentals of mathematics and the engineering sciences. Emphasiz-

ing these particular features will go far toward realization of the first objectives of engineering education; that of providing an adequate technical foundation. We have felt for some time that the engineering school graduate was not, in a large percentage of cases, a really well educated individual. Quite frequently he lacks proper perspective and is inclined to place undue weight on some special feature of a problem. Many of these individuals lack ability to communicate their ideas and their understanding of what are generally known as the humanities leaves considerable to be desired. The objective as set forth in the report of developing the individual along these lines meets with our full approval.

Mr. Linder has suggested that we use this question "Are we convinced that the recommendations of the report will, if put into effect, produce the broadly trained, versatile young men the industry must have as recruits?"

As a broad general answer to such a question, I would say that we are not convinced that putting these recommendations into effect will produce such men. However, I would modify this general statement by saying that it is our opinion that the following of these recommendations will constitute a definite step in the direction of the desired objective. It is our opinion that additional work must be done before we can realize the goal mentioned above. Further studies should involve both educators and representatives of industry.

The Foreword of the report emphasizes the fact that very little space is given to an analysis and evaluation of graduate study in engineering. However, some reference is made to graduate study and certain questions regarding it are raised.

On page 18 of the report the following statement appears:

"5. The demand of industry for engineers with more than baccalaureate education has resulted in extensive part-time programs at the graduate level for industrial employees."

Following this statement a number of questions are raised. The first of these is: "Do such programs meet high graduate standards?" Does this question refer to academic standards or to standards set by industry? If academic standards are implied, we might counter this question with one somewhat as follows: Is it necessary that they should meet so-called high graduate standards? Is it not possible that such courses might be given for the express purpose of improving the knowledge and usefulness of individuals in a particular field? It seems to me that before we can answer such questions it is necessary that we be sure of the objectives of such a course of study. Under this same number a question is raised regarding the sufficiency of part-time study. I think considerable care should be used in answering this question. In the past a great many individuals have been forced to rely on part-time study to obtain important parts of their technical and other education. It is undoubtedly true that this condition will continue in the future. It seems to us therefore that one of the problems in connection with engineering education is to see that part-time study of such character as to provide degree programs comparable with those involving full time resident study are available to those who require such education.

To summarize, it is our opinion that the function of engineering education is to provide a well educated individual properly grounded in both technical and general educational fields who is in a position to continue his education after leaving college. We should bear in mind that the purpose of engineering education is to prepare individuals to implement and lead in the development of a continuously growing and expanding economy.

Very truly yours,
WESTERN MASSACHUSETTS
ELECTRIC COMPANY

Signed: J. W. Bennett,
Chief Engineer

Southern California Edison Company, Ltd.
Edison Building
Los Angeles 53, California
October 8, 1954
Mr. J. F. Davenport
Vice President and General Manager

A short time ago you sent me a letter that you had received from Mr. Clarence H. Linder, Vice President, General Electric Company. At that time you requested that I study the Interim Report of the Committee on Evaluation of Engineering Education that came with Mr. Linder's letter and offer any ideas concerning it. I asked Mr. R. H. Adams to help with this and our combined observations follow:

After reading the report we believe that the major question concerns the balance between fundamentals (basic science —engineering science) and specialization (practice). Two quotations from the report lend emphasis to this:

"The instructional goals of engineering education include helping the student to learn to deal with new situations in terms of fundamental principles on his own initiative, and with confidence and sound judgment. The goals should include motivation to keep abreast of the new developments in science and technology, and to continue to grow intellectually in both professional and cultural areas throughout life."

Our feeling about practice coincides with another quotation from the report:

"The engineering art taught in colleges will normally reflect practice that is already, in part, obsolete since teachers' knowledge of practice becomes rapidly outdated."

The Interim Report suggests the time distribution in scientifically oriented engineering curricula as shown below:

(1) Humanistic-Social	21 semester hours
(2) Math and Basic Science (about equal in weight)	36 semester hours
(3) Engineering Science	36 semester hours
(4) Required Technology	7 semester hours
Total for the Common Stem	100 semester hours
(5) Major Departmental Sequence of Engineering Analysis, Design and Engineering Systems	21 semester hours
(6) Options or Electives in (a) Humanistic-Social, (b) Management, (c) Basic Science, (d) Engineering Science, (e) Research or Thesis, (f) Engineering Analysis and Design, (g) Technology	17 semester hours
Total for the 4-Year Curriculum	138 semester hours

We were interested to see how the four major schools of engineering in the State of California compared with this proposed course of study. Consequently, we sent for the catalogues of the schools of engineering of California Institute of Technology, University of California, University of Southern California and Stanford University. The point of comparison was to determine whether or not any of these colleges were conducting their schools of engineering along the lines proposed by the report which would mean that approximately three years out of the four would be spent in the area of humanistic-social studies, mathematics, basic science, engineering science and related technology. This would leave a little more than the normal number of semester hours of the year for specialization and optional studies connected with that specialization.

Stanford University closely parallels the time distribution shown in the chart above. The California Institute of Technology approaches the recommendations made above but the general basic courses for all types of engineering are not as

uniform as those of Stanford University. The specialty subjects at the California Institute of Technology are more widely disbursed through the four years than those of Stanford. The University of California and the University of Southern California are farther out of balance between fundamentals and specialization subjects. Except for the University of California the four Universities meet the requirements (total number of semester hours) of the report in the humanistic-social area. None of the schools offered all the work that the report recommends in mathematics, electronics, chemistry and general physics, particularly in the area of nuclear and solid state physics.

It would seem then that Stanford University and California Institute of Technology are attempting to teach the fundamentals with enough specialization so that the graduate would be able to secure and develop on a job.

The report stresses the need for study in the humanistic-social areas of education. We feel that this training is essential to any college graduate. The ability to communicate clearly becomes more important as our society becomes more complex both socially and economically. Training in the principles of human behavior (human relations) is an asset that is recognized in all phases of living.

The report states it is more important that a teacher be an expert in his field than that he have a certain number or kinds of degrees. From our own experience in teaching we can lend wholehearted support to this idea. The instructor whose chief interest is in his subject gives purpose and meaning to his teaching that cannot be accomplished by the "degree collector."

If this new emphasis in engineering will create an inquisitive attitude in students so that they will not "rest on their degree" but will actually begin to become educated as they apply their information and training on some actual job, the idea should have the concentrated support of business and industry.

It was mentioned above that fundamentals change slowly. In education, practice has changed slowly also. We feel that the interim report is an attempt to apply a new workable practice to the old educational fundamentals.

Yours very truly,

K. K. ALLEN,
Manager of
Industrial Relations

To: A.S.E.E. Committee on Evaluation of Engineering Education

The University of Illinois committee has been unable to reach anything approaching unanimity with regard to the major implications of the report, so that it appeared inadvisable to attempt to express a majority opinion. Rather, this preliminary report is intended to present the principal objections raised by various members of the committee and to point up in particular certain phases of the Interim Report which were considered to be ambiguous.

Most of the committee members were in agreement that the manner of implementation of the stated objectives as proposed on pages 21 and 22 does not appear to be consistent with the objectives themselves. Let us assume that a major objective of the Interim Report is a "broadening and deepening of the basic science content throughout all of the scientific and engineering portions of the curricula," to borrow an expression from Secretary A. B. Bronwell. It appears that the intent of the authors is to achieve this broadening by covering in some manner or other the nine topics listed as engineering sciences in addition to adding some material in physics and chemistry. A large portion of our committee seriously doubt that many of the so-called engineering sciences can or will be presented in the manner of a logical development from basic scientific

principles within the span of a single semester course. This is particularly true when such a course is presented by one department for the students in another branch of engineering. Certainly, as now taught, many of such courses do not merit the term "engineering science." There is serious doubt in our minds that the requirement of a number of courses of this type will achieve the type of broadening apparently intended by the statement of the objectives.

Although the Interim Report qualifies its recommendations again and again, it still carries the implication that all engineering curricula should include all nine of the so-called engineering sciences to the extent of a specified minimum in semester hours. This seems to us to be much too restrictive. The impact of a requirement of this type upon certain curricula now accredited by E.C.P.D. would be shattering. In one case, at the University of Illinois, it would require shifting from 15 to 20 semester hours, depending upon the interpretation, from the major field to the engineering science block of courses. Surely, the authors of the Interim Report did not envision this type of emasculation.

The committee is more inclined to favor, instead, a proposal in which any given curriculum might be expected to include perhaps six of the nine topics listed, but with no specification set on the number of hours devoted to each. In June 1954, the University of Illinois College of Engineering adopted a common core including six of the nine subjects listed as engineering sciences, specifying the coverage by topical outline rather than by specification of hours. Moreover, it is reasonable to expect that in a given curriculum considerably more than 6 semester hours of "engineering science" may fall within the major field of specialization. To cite an extreme case, curricula in Electrical Engineering commonly include 15–20 semester hours of basic material on circuits, fields and electronics. It is logical that much of this material should be included in the scientific block of courses. This, of course, means that the "common stem" for all curricula would be reduced somewhat from that recommended.

In order to insure breadth of coverage, however, it could be proposed that each curriculum should include significant offerings of material, presented as a basic science with application to engineering problems, in each of the following areas (over and above the material presented in elementary physics):

1. Mechanics (Statics, Dynamics, Fluid Mechanics, Resistance of Materials)
2. Heat (Thermodynamics, Heat Transfer)
3. Electricity (Electrical Circuits, Fields, Electronics)

The above grouping represents a more appropriate distribution of emphasis, we believe, than the listing of the nine topics separately, as is done in the Interim Report. A fourth group including engineering materials and physical metallurgy was considered but was not included because these topics do not lend themselves as well to presentation as "engineering science." However, with recent rapid advances in solid state physics, the day is drawing near when these subjects can and will be developed in a more logical manner than has been possible in the past. When this is achieved, this area might well be considered to be an additional essential branch of "engineering science."

The term "engineering science" and the listing of the nine topics under that heading has given our sub-committee no end of trouble. In the first place, "engigineering science" is defined only by a listing of topics, which, in the minds of some, is no definition at all. Secondly, the topics listed as engineering sciences can be and are being presented variously as basic science, as engineering application of basic science, as the applications of empiricisms, or as engineering art, depending upon the topic and where it is being taught. To many readers, the topics listed will mean courses as they are presented today, and unless it is brought

out forcibly that something else is meant there will be continuing opposition to the inclusion of many of these topics in a listing of "engineering sciences." A clarification of the term "engineering science" would be extremely helpful to the interpretation of the real meaning of the report.

The committee has considered several other phases of the Interim Report, though briefly. There appeared to be general concurrence that the material on selection of faculty was sound, though a few would prefer that less emphasis be given to the importance of the Ph.D. degree in contrast to other measures of competence and potential.

The committee is in general agreement that an additional course in mathematics beyond calculus is desirable for practically all engineering students. There was some belief that the additional course should not be fixed specifically as differential equations, in accord with the view expressed on page 21 of the Interim Report.

It is hoped that the views expressed will be of some assistance to the committee in their revision of the Interim Report.

W. R. CHEDSEY
J. C. DIETZ
V. P. HESSLER
H. H. HILTON
J. E. PEARSON
W. S. POLLARD
C. P. SLICHTER
W. E. BLACK, *Chairman, Committee on Evaluation of Engineering Education*

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR AND ASSISTANT OR ASSOCIATE professor for teaching and research in field of metals processing. Courses given in basic and production machine tools. Should be interested in and qualified for some research in metal cutting; capable of guiding graduate students at advanced levels. Salary and rank dependent on education and experience. East. White JA–1.

INSTRUCTOR IN CIVIL ENGINEERING, preferably with M.S. degree and practical or teaching experience; major interest desired but not required—sanitary engineering. Position open fall 1955. Department of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Indiana.

INSTRUCTOR OR ASSISTANT PROFESSOR with M.S. in Civil Engineering to teach surveying, soil mechanics, fluid mechanics, and normal civil engineering laboratories. Should be active in technical and professional organizations. Salary and academic rank open depending on degree and experience. Position starts September, 1955. Location, Ohio. Write JA–2.

ASSISTANT OR ASSOCIATE PROFESSOR in Electrical Engineering with an advanced degree and experience, to teach in the power field. Should be active in technical and professional organizations. Degree and experience to determine academic rank and salary. Position starts September, 1955. Location, Ohio. Write JA–3.

Teaching Positions Available are also listed on Page 430

Report on the Carnegie Conference on the Impact of Solid State Science on Engineering Materials

By GLENN MURPHY, *Conference Secretary*

Professor and Head of Aeronautical Engineering, Iowa State College

Representatives from about 45 colleges and universities and from nearly a score of industrial and government organizations met at Carnegie Institute of Technology, 21–25 June, 1954 to discuss the latest developments in solid state science and to consider the ways and means of incorporating these developments into engineering curricula. The conference was sponsored by Carnegie Institute of Technology, 21–25 June 1954 to discuss the the active cooperation of the National Science Foundation and ASEE. Assistant Dean J. W. Graham and Prof. J. E. Goldman were the conference chairmen. General plans for the meeting had been made at the Allerton conference in March.*

The papers that were presented on the technical phases of the developments in solid state science are scheduled to be published early in 1955 in a volume edited by Professor Goldman. The presentations included discussions on the Structure of Matter by Prof. Harvey Brooks of Harvard and Prof. J. Bardeen of the Univ. of Illinois; Phase Transformations and Their Influence on Metallic Properties by Prof. H. Jones of Imperial College and Carnegie Inst. of Tech., with Applications of Modern Theory of Metals by Prof. R. Smoluchowski of Carnegie Inst. of Tech.; Surface Effects and Properties by Prof. R. Gomer of the Univ. of Chicago; Introduction to Dislocations and Plastic Theory by Prof. Smoluchowski, Plastic Properties by Prof. H. Paxton of Carnegie Inst. of Tech., Phase Transformations by Prof. T. A. Read of Columbia Univ., and Grain Boundary Effects by Prof. Earl Parker of the Univ. of California. The session on Magnetic Properties included papers by Prof. Goldman and Dr. R. M. Bozorth of Bell Telephone Labs. A paper on Semiconductor Theory by Prof. K. Lark-Horowitz of Purdue was given by Prof. B. R. Gossick, followed by a discussion of Applications to Engineering Devices by Prof. W. J. Leivo of Carnegie Inst. of Tech. Dr. Harrison Davies of Mellon Institute talked on Glass Science and Technology. A discussion of the Theory of the Properties of Plastics and High Polymers was presented by Dr. T. Alfrey, Jr. of Dow Chemical Corp. and the final technical paper of the conference was on the Physics and Chemistry of Cements by Dr. S. Brunauer of the Portland Cement Association.

The keynote of the educational aspects of the problem was struck by Dean B. R. Teare, Jr. in his opening remarks. He stated that the purpose of the conference was to review the content of solid state science in relation to materials, to consider what this science has to offer engineers and to help determine what place

* A Report on the University of Illinois Summer Institute Conference on Solid State Physics in the Engineering Curriculum, Glenn Murphy, *Journal of Engineering Education*, **44**: 494–498, May, 1954.

it should have in engineering education. He indicated six groups of pertinent questions.

1. What are the essentials of solid state physics as they relate to engineering education?
2. How can they best be taught, by whom, at what level, in what year, for how many credits and with or without laboratory?
3. How can solid state science be utilized in subsequent engineering courses to realize its full value?
4. What prerequisites in mathematics and physics are needed?
5. What special difficulties are likely to be encountered?
6. How can space and time be found in curricula for this material?

Formal discussion of these and allied questions took place at two sessions during the latter part of the conference following most of the technical presentations.

Taking part in the discussion of the educational aspects were representatives of curricula in aeronautical engineering, ceramic engineering, civil engineering, chemical engineering, electrical engineering, engineering mechanics, mechanical engineering, metallurgical engineering and physics. There were more representatives from physics departments than from any other department, with electrical engineering second. The other curricular departments were about evenly divided in representation.

Recurrent Theme

Throughout the open discussion there was the recurrent theme that the engineering developments of the next quarter century or more will be closely linked to the research that is being done today and that those phases of research that will contribute to a better understanding of materials are of prime importance. In addition, it was apparent that there existed an appreciation of the fact that the present limitations in many engineering developments is a direct result of the limitations in our knowledge of the properties of materials, and that those concepts and principles useful in explaining or pointing toward an explanation of how materials will behave in stress, electrical or magnetic fields are particularly significant in engineering at the present time. An undertone of urgency was apparent—an expressed indication that immediate attention needs to be given to incorporating the concepts and principles into some of those curricula where they do not already exist. On the other hand, is was clearly recognized that extensive training in solid state physics would be justified for only a small percentage of the engineering students, and that it would not be desirable at the present time to introduce a required course in solid state physics at all schools and in all curricula.

However, all of those who spoke in the open discussion favored the inclusion of at least some aspects of solid state science in engineering curricula, thereby confirming the resolution passed at the Allerton Conference. From the discussion it was evident that the term "solid state science" was being used to refer to the group of concepts and principles essential as a basis for explaining or pointing toward an explanation of the behavior of materials in stress, electrical or magnetic fields. Several speakers indicated that the principles have already been incorporated into existing engineering programs, particularly in electrical and metallurgical engineering. In a few instances an introduction to the field is being given to all engineering students in the general physics courses.

During the discussion it was brought out that there are four ways in which these concepts and principles may be made a part of the training of the engineering student. These are (a) the enrichment of existing courses in the various curricula, (b) the replacement of a specific portion of present appropriate courses with up-to-date material, (c) the utilization of available courses (generally in physics) as electives, and (d) the establishment of specific new courses in solid state physics or solid state science.

By the enrichment of existing courses is meant the use of appropriate examples to illustrate the application of the principles to the subject matter of the course under consideration. For example, in a course in machine design the subject of work hardening of metals during fabrication might be introduced as illustrating a concept of how dislocation theory is related to the alteration of the mechanical properties of metals. From the standpoint of the curriculum builder, this approach appears to offer certain advantages. It puts the material before the student without having to drop any technical specialties or cut short the social-humanistic percentage of the curriculum. It also strengthens the tie between principles and their applications in various courses and this is good. However, there are two weaknesses to this approach. One is that it assumes that each instructor is familiar with the principles under consideration, and the other is that even it he does know the principles that he will be willing to displace other examples and illustrations of other principles that he wishes to stress in order to introduce a consideration of concepts which frequently are qualitative rather than quantitative.

Certainly much can be done with this technique, and it may be used to great advantage in helping to answer questions that arise in class. In fact, it will often be more meaningful when utilized in that way. Effective use of the technique is dependent upon the instructor's knowing just what the student has had in his prerequisite science courses, and this information can be developed through interdepartmental committees. At least one university has set up groups of interdepartmental committees which are helping to achieve closer cooperation between science and engineering.

The second technique, that of replacing a specific portion of present courses with appropriate material in the field, is likewise attractive from the standpoint that it does not involve discarding favorite advanced specialities in any curriculum. Certainly two weeks' time can be gained in the average course in engineering materials by discarding unessential descriptive material thereby providing an opportunity to introduce some solid state physics. The method of replacement has been used in electrical engineering curricula at various schools to make space for a brief treatment of semiconductors and their applications in transistors. More solid state science can be introduced into metallurgy courses in this way.

One question to be raised in conjunction with the partial replacement approach is whether a period of perhaps two weeks is adequate to permit a fundamental approach or whether that length of time is adequate only for a few examples. The answer to the question must be considered in the light of the extent of prerequisite courses.

Elective Courses

Elective courses in solid state physics are available at a number of schools, usually in the physics department but in a few instances in engineering. The indications at the Carnegie Conference, as at the Allerton Conference, are that very few engineering undergraduate students elect such courses. For those students contemplating advanced study with a career in research, an undergraduate course in solid state physics appears highly desirable. However, at the time that there is an opportunity to elect such a course, the student can hardly be expected to have made an unalterable decision to enter research. Another disadvantage inherent in the exclusive use of the free elective system for providing the training in solid state physics is that the subject matter is off the beaten track for the majority of students, and only a relatively small number will have the opportunity of learning of its potentialities.

The establishment of new courses in solid state science for engineers was cited as the fourth method of introducing the subject matter into the various curricula. These could be in the form of a general

course for all engineers with the contents approximately as outlined at the Allerton Conference and extending over one or two semesters, or they could be in the forms of more specialized engineering courses similar to those being taught at some universities.

The introduction of a new required course automatically raises the question of what it will necessarily displace. Suggested answers to this question may be classified into three groups. One solution is to drop a free elective, a technical specialty or a course concerned with those aspects of the art of engineering that are in all probability obsolete before they reach the student in a textbook. A second possible solution lies in the elimination of duplication. Possible duplication between the work taught in physics and the various engineering departments in the subject field of mechanics, thermodynamics, and electricity and magnetism have been cited for consideration. The question of the importance of differences in viewpoint and methods of approach in the various departments must be carefully considered before wholesale removal of courses is warranted. The third class of solutions includes those related to an increase in teaching efficiency. In some instances it may be possible to telescope sequence courses, thereby gaining some time, through elimination of unnecessary detail in each and through more effective teaching.

Related aspects, including an indication of a sincere desire to give the student the best possible education during his college career, are evident from the following ideas expressed during the open discussion.

"At present there are relatively few examples of the application of solid state physics, but it is important to develop in the undergraduate a point of view so that he can recognize the elements of the problems he will later meet."

"A better understanding of materials could be built up if the students had more solid state physics—but we must not neglect the art of engineering. Chemistry, physics and mathematics all should be re-evaluated."

"The why of phenomena as well as the how must be part of the approach in basic courses."

"The elementary course must be qualitative rather than quantitative in nature, and should not replace the conventional elementary physics."

"More time could be spent on thermodynamics, bond theory, valence and bonds early in chemistry to lay the basis for later applications."

"Relatively little theory should be introduced in an elementary course, but an understanding is important."

"Part of the approach in a basic course is to develop a feeling on the part of the students for the order of magnitude of various effects."

"A suitable course can be introduced at the undergraduate level."

"It will be hard to lay out a single program suitable for all engineering students."

"The subject matter outlined in the Allerton Conference report can be added to the students' program provided they have a sound basis in chemistry and mechanics. The exceptions and limitations can be treated in later courses."

"The material outlined at the Allerton Conference should be covered in two sophomore courses in physics and should prepare the graduate to read the current literature in the field."

"Once a few schools start using solid state physics in engineering curricula, others will follow."

"Engineers would like to see a method developed for getting from the structure of a crystal to the stress-strain diagram at a given temperature."

"One possibility is to introduce a survey foundation course to point out the modern viewpoint and then to extend the treatment in later courses."

"With four semesters of physics required for engineers, Rensselaer has a course similar to the introductory course

outlined in the report of the Allerton Conference. This introduces the basic background of solid state physics but cannot give a quantitative treatment at the undergraduate level. The entire fourth semester is devoted to modern physics with particular emphasis on engineering."

"The principal problem is that of educating the faculty."

General Agreement

From the information on existing courses and from the ideas expressed in the discussion (of which the foregoing are only samples) it was apparent that there was general agreement with the recommendation of the Allerton Conference that work in solid state physics be introduced into the engineering curricula, and it was also apparent that no one of the plans outlined was predominantly favored over the others. There was general agreement that the selection of the plan or combination of plans at a given institution must be governed by the institution, the objectives of the individual curricula and the interests and aptitudes of the staff members concerned.

It was voted to recommend that item III of the resolution adopted at the Allerton Conference be amended to read

"that the implementation of these objectives be achieved through the cooperative efforts of engineering and science departments at each institution."

In closing the conference Dean R. F. Mehl of Carnegie Institute of Technology pointed out the revolutionary impetus that had been given to metallurgical engineering twenty-five years ago by the introduction of the concepts of chemistry and solid state physics, and indicated that a similar impetus was available in the other engineering fields through the application of solid state principles and concepts. He advised that the material not be isolated in a single course, but be introduced wherever possible in the various engineering courses where it applies.

A vote of thanks to Dean Teare, Asst. Dean Graham, and Prof. Goldman of Carnegie Institute of Technology, to the lecturers, and to the University of Illinois, the National Science Foundation and ASEE for organizing an extremely stimulating conference was heartily approved.

College Notes

A $250,000 Ford Foundation grant to **Carnegie Institute of Technology** was announced. The grant will be used in Carnegie's Graduate School of Industrial Administration to finance fellowships for men looking toward careers in teaching and research in industrial administration. Activities under the new grant will supplement the Graduate School's basic objectives of training men for careers in business and industry, and its present research into the behavior of business organizations, effective decision making, operations analysis, and related areas. The new $250,000 grant supplements earlier Ford Foundation awards of $167,000 to Carnegie's Graduate School of Industrial Administration for research into more effective business organizations and decision-making.

Mathematics for Graduate Work in Engineering*

By JOHN W. CELL

Professor of Mathematics, North Carolina State College

Since much advanced mathematics is necessary to the understanding of graduate work in any field of engineering and to the reading of technical papers in that field; since much basic but advanced physics and engineering is likewise needed; and, further, since the study of mathematics must include derivations, illustrations, and applications; therefore required instruction in mathematics for advanced undergraduate and graduate students in engineering must be different from that given to students of pure mathematics. This does not mean that such courses in applied mathematics would lack rigor. This does imply that the material in any one topic must be less comprehensive than that given in specialized courses in pure mathematics.

What is pertinent background in which to consider this required mathematics? In the first place ours is a period of experimentation in education at all levels and in all areas. There is more to learn in any one field today than there was twenty years ago and the content continues to grow. Because this is especially true in mathematics, committees from the Mathematics Association and the National Research Council are at work in the study of both content and objectives of the mathematics for high school instruction and for that normally studied in the first two years of college mathematics. In high school curricula some experimentation is underway, for example, to combine plane and solid geometry into a single-year course and to spend the gained semester on other mathematics. The experiments being conducted at the University of Illinois in improving high school instruction for prospective engineering students are being watched with great interest. At the college level the growing emphasis on the teaching of a combined course in analytic geometry and calculus is a part of this experimentation and is reflected in the number of textbooks now available for this type of course.

One aspect of this experimentation concerns motivation. In colleges where calculus is used in the instruction in physics and where the teaching of mathematics and physics is somewhat correlated, there is an automatic motivation for the student in his study of mathematics. This motivation is necessary if students are to learn elementary mathematics and not merely earn course credits. Engineering problems courses for freshmen engineering students can greatly aid in this motivation.

In colleges where mathematics is really used in the junior and senior courses in engineering instead of being avoided, motivation for the study of mathematics is transmitted by the upperclassman to the freshman and sophomore. Such utilization of mathematics at the upper level can serve in other important ways. Let me illustrate with the question of beam problems in strength of materials. Here the electrical engineering student would gain significant background for his later study in transients if the beam problems were solved by the double-integration method.

*Presented at the Mechanics Summer School sponsored by A.S.E.E. at Urbana, Illinois, June, 1954.

	Bronwell	Franklin	Guillemin	Hildebrand	Kaplan	Karman and Biot	Margenau and Murphy	Murnaghan	Pipes	Reddick and Miller	Reed and Reed	Schelkunoff	Smith	Sohon	Sokolnikoff	Wylie
Infinite Series	x	x		x	x				x	x		x	x		x	x
Fourier Series	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fourier Integral	x		x	x			x		x				x			x
Determinants and Matrices			x			x	x		x		x		x	x	x	x
Solution of Equations	x					x			x		x	x		x	x	
Ordinary Differential Equations	x	x		x	x	x	x		x	x	x	x		x	x	x
Partial Differentiation, etc.	x	x			x		x		x	x		x	x		x	x
Multiple Integration, Improper Integrals, etc.		x		x	x							x	x		x	x
Finite Differences, Interpolation						x			x					x		
Elliptic Integrals	x	x		x		x	x			x			x		x	
Gamma, Beta, Error Functions, etc.		x		x			x		x	x		x	x	x		x
Bessel Functions	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Vector Analysis	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Partial Differential Equations	x	x		x	x		x	x	x	x	x	x		x	x	x
Complex Variables	x	x	x	x	x				x	x	x	x	x			x
Operational Mathematics	x		x	x		x	x	x	x	x	x	x	x			x
Empirical Formulas, Curve Fitting, Numerical Methods							x					x			x	x
Calculus of Variations		x					x	x	x				x			
Probability										x			x		x	
Space Geometry		x			x		x					x	x			
Integral Equations							x	x					x			
Tensor Analysis													x			
Nonlinear Problems									x							
Linear Transformations			x										x			
Quadratic Forms			x					x					x			
Orthogonal Functions			x	x	x								x			
Partial and Continued Fractions			x								x					
Dimensional Analysis														x		

Advanced Mathematics in Physics and Engineering by Arthur Bronwell (Electrical Engineering), McGraw-Hill, 1953

Methods of Advanced Calculus by Philip Franklin (Mathematics), McGraw-Hill, 1944

The Mathematics of Circuit Analysis by E. A. Guillemin (Electrical Communications), John Wiley and Sons, 1949

Advanced Calculus for Engineers by F. B. Hildebrand (Mathematics), Prentice-Hall, 1949

Advanced Calculus by Wilfred Kaplan (Mathematics), Addison-Wesley, 1952

Mathematical Methods in Engineering by T. Karman (Aeronautics) and M. A. Biot (Mechanics), McGraw-Hill, 1940

The Mathematics of Physics and Chemistry by H. Margenau (Physics) and G. M. Murphy (Chemistry), Van Nostrand, 1952

Introduction to Applied Mathematics by F. D. Murnaghan (Mathematics), John Wiley and Sons, 1948

Applied Mathematics for Engineers and Physicists by Louis A. Pipes (Electrical Engineering), McGraw-Hill, 1946

Advanced Mathematics for Engineers by H. W. Reddick (Mathematics) and F. H. Miller (Mathematics), John Wiley and Sons, 1947

Mathematical Methods in Electrical Engineering by Myril B. Reed (Electrical

The other two methods could then be left to a second course in strength of materials or to a succeeding course in civil engineering where students would learn these useful concepts. The neglect of the double-integration method is an evidence that all of us tend to teach our courses as though all our students were majors in our particular fields.

More Emphasis on Understanding

Motivation is inseparable from good teaching and intelligent study. Good engineering students should not be "cook-book specialists" in mathematics; mathematics is more than formulas in a handbook! Instruction in mathematics should be divided between theory, drill problems, and applications. More emphasis should be placed on understanding and less on memorization, and time should be given to formulation of problems. Professor Meriam of the University of California states that "instruction in mathematics is generally weak for its scanty emphasis on the formulation of problems"; and other prominent engineering teachers have made the same contention.

Prospective graduate students should as undergraduates take more mathematics and physics than the present minimum requirement. Courses such as the one in engineering problems at Carnegie Institute of Technology for juniors and seniors in electrical and mechanical engineering can aid greatly in developing mathematics beyond calculus. Dean Teare of that institution writes that "the how of teaching (1) should help the student learn to analyze problems that are new to him with well-ordered thinking and (2) should prepare him to go on learning in the field of mathematics on his own initiative and without the guidance of a teacher."

The usual two years of required mathematics for engineering students, however, is decidedly inadequate. Professor Pletta of Virginia Polytechnic Institute writes that such students are "absolutely illiterate technically and unable to read the literature in any field without the equivalent of four years of mathematics." If additional mathematics cannot be given to all of the engineering students, at least there should be some method found to distinguish prospective graduate students among the rising juniors and to give them additional mathematics and physics in their undergraduate work.

These students should take at least one additional year of mathematics in their undergraduate programs if they are to derive maximum benefit from their early graduate study. Before discussing the content of that year course let us compare the content of a number of available texts, as shown on the next two pages. Some of these are written by electrical engineers, some by physicists, some by mathematicians, and one by an aerodynamicist and an engineering mechanics professor. Some of these are unfortunately of the cook-book variety; others, however, give a more balanced treatment of mathematics and applications.

An analysis of these texts will show agreement that this year of advanced undergraduate mathematics should contain

a. Elementary ordinary differential equations,
b. Infinite series,
c. Fourier series,
d. Bessel and related functions,
e. Vector analysis,

Engineering) and Georgia B. Reed (Electrical Engineering), Harper and Brothers, 1951

Applied Mathematics for Engineers and Scientists by S. A. Schelkunoff (Technical Staff of Bell Telephone Laboratories), Van Nostrand, 1948

Mathematical Methods for Scientists and Engineers by Lloyd P. Smith (Physics), Prentice-Hall, 1953

Engineering Mathematics by Harry Sohon (Electrical Engineering), Van Nostrand, 1944

Higher Mathematics for Engineers and Physicists by Ivan S. Sokolnikoff (Mathematics) and Elizabeth S. Sokolnikoff (Mathematics), McGraw-Hill, 1941

Advanced Engineering Mathematics by C. R. Wylie, Jr. (Mathematics), McGraw-Hill, 1951

f. Partial differentiation and elementary partial differential equations,
g. Integration including multiple integration and improper integrals.

It is my contention that this is enough material for a one-year course if it is correctly taught. In the first topic I am supposing that trick method of solving special differential equations have been omitted from this course. Linear differential equations with constant coefficients are to be emphasized and particular solutions are to be obtained by several methods, including that of variation of parameters. The portion on differential equations should also include series solutions and brief attention to graphical and numerical methods of solution. Finally, I am supposing that differential equations are carefully derived from physical problems, solved by appropriate methods, and the results interpreted in terms of the given problem. The same type of comment applies to the material of the other six topics.

Modifications of this content would be made at some colleges where there are exceptions to customary practices. For example, if elementary mechanics is taught by vector methods, as is being done, for example, at Cornell University and at Carnegie Institute of Technology, vector analysis in the proposed course could be either compressed or eliminated.

The discussion thus far has been devoted to background and to this one-year advanced undergraduate mathematics course. Let us next consider the content of three one-year courses at the graduate level in mathematics. The first of these would be required of master's-degree students and the other two additionally would be taken by Ph.D. students. As we discuss these courses, we must consider not only their present adequacy but also their value for the next ten years. It is pertinent to call attention to the joint committee from the American Mathematics Association and the American Society of Engineering Education under the chairmanship of Dr. G. B. Thomas, Jr. of M.I.T. This committe is studying the content and objectives of engineering mathematics at the undergraduate and graduate levels and is to make recommendations for improvement.

Among these newer requirements, the solutions of non-linear problems and of more complicated ordinary and partial differential equations are of increasing concern in many branches of engineering. Methods of solution embrace numerical methods such as the relaxation method, and the growing use of analog and digital electronic computers. Parenthetically, the need in the next two or three years for between one and two thousand applied mathematicians to man these electronic computers is allied very closely with this discussion of course content and course objectives.

With this overall background we may now consider these three one-year graduate courses in detail.

1. The first one-year course would consist of
   a. Complex variables including conformal mapping and residue theory;
   b. Operational mathematics including not only Laplace transforms but also the various Fourier transforms, Hankel transforms, and finite transforms;
   c. Solution of problems in ordinary and partial linear differential equations.

This course would include derivations in mathematics. For example, I would derive the usual Cauchy equations for an analytic function. But I would merely outline the proof of the fundamental Cauchy theorem about the integral of an analytic function around a simple closed curve and would not go through the detailed derivation.

This course would emphasize total problems; that is, their formulation, their solution, and their implications. Partial differential equations would be carefully derived by both the delta and the differential languages and would be solved by appropriate methods such as separation of variables and transform methods; the im-

plications of the solutions would be discussed. In some cases the formally obtained solutions would be verified carefully, and in other cases this step would be waived.

The various fields of engineering and science provide sources of total problems. For instance, applications of conformal mapping would be made to field problems such as those in fluid mechanics. Transform methods would be applied to solutions of problems in ordinary and partial linear differential equations, to integral equations, and to difference equations. Boussinesq's results in elasticity, for example, are solutions of partial differential equations obtainable by these transform methods. (Drill in residue theory would occur in obtaining inverse Laplace transforms of partial differential equations.) Problems in wave motion, heat and diffusion, and in elasticity would be solved as partial differential equations.

Among the appropriate texts for this course are the three books by Professor R. V. Churchill on *Complex Variables, Modern Operational Mathematics in Engineering,* and *Boundary Value Problems,* all published by McGraw-Hill; and the pocket-sized book by C. J. Tranter on *Integral Transforms in Mathematical Physics,* published by John Wiley and Sons.

2. A second one-year course would include the following topics:
   a. Determinants and matrices,
   b. Advanced vector analysis,
   c. Tensor analysis,
   d. Space geometry.

To avoid repetitiousness I shall omit from the discussion of the other two year courses all but a brief mention of their applications.

Applications of determinants and matrices would be made to stability criteria (e.g. Routh's), to solution of simultaneous equations, to the concepts of superposition and reciprocity, etc. Applications of tensor analysis in elasticity are readily available.

3. The third one-year course would include
   a. Calculus of variations,
   b. Integral equations,
   c. Finite differences and difference equations,
   d. Perturbation methods of solution and advanced boundary value problems,
   e. Numerical methods,
   f. Non-linear problems.

Applications of these topics would be made appropriately and need not be detailed here.

In both the second and third courses some of the mathematics would be presented rigorously and some would be given in less detail. Applied problems would include formulation of the mathematics problem, the solution of that problem by one or sometimes two methods, and an analysis and interpretation of the results.

Textbooks such as *Methods of Applied Mathematics* by F. B. Hildebrand of M.I.T. (Prentice-Hall, 1952), *Mathematical Methods for Scientists and Engineers* by L. P. Smith of Cornell University (Prentice-Hall, 1953), and *Applied Mathematics for Engineers and Scientists* by Schelkunoff (Van Nostrand, 1948) could be used appropriately for some of the material of the second and third courses. But more such books are urgently needed.

Summary

Let me summarize briefly.

One year of advanced undergraduate mathematics and three one-year courses of graduate work have been outlined as required material for Ph.D. students in engineering; half of this would be required of master's-degree students. These courses would include some mathematics rigor, they would be less comprehensive of individual topics than is traditional in mathematics, and they would include the study of total problems: formulation, solution, interpretation. It is my conviction that the proposed courses provide in Dean Teare's words "root concepts on which further education can be built."

Progress in Teaching English to Engineers*

By C. A. BROWN

Chairman, English Department, General Motors Institute

Testimony that engineering graduates must have command of the arts of communication is not lacking. Employers are perfectly willing to make statements to that effect. All of us can collect an imposing array of such statements, some critical, some helpful. On the other hand the evidence in engineering journals is that engineers do write. Some of them write quite well.

In the face of criticism, however, almost instinctively our defenses bristle. We talk about inadequate preparation on the part of students, inadequate professional opportunity for teachers, inadequate time provided for the proper courses, and so on. While some of these reasons may be appropriate in some institutions, I am convinced that our real problem for a long time was the lack of communication between the English departments on the one hand and the engineering faculties and industrial employers on the other. Some of the responsibility rests upon industry, but certainly some of it rests upon us.

I can illustrate from the broader problem of engineering education and the extent to which it does or does not fill the needs of industry. There are some in industry who have been critical of the engineering graduate because "he can not do anything." They have attempted to apply pressure upon the engineering colleges to equip graduates with specific skills so that they will be immediately useful to their employers. This would lead to some form of training other than professional education as I understand it. Fortunately most of our engineering colleges have resisted this pressure.

Others have insisted that the engineering graduate know "the fundamentals of engineering." Upon this foundation each industry would train or educate the graduate in the applications of those fundamentals in the particular industry in which he is employed. Now the problem becomes one of agreeing upon what constitute the fundamentals. That problem, in engineering education, is being solved.

The desire to have college graduates who can write and speak clearly reflects some of the same confusion. Some industrialists want engineering graduates trained to write a particular kind of report. Others insist upon "fundamentals." Apparently they believe that each graduate should be supplied with an orthodox set of formulas for preparing reports that will meet specific situations. Industrialists' ideas of what constitute fundamentals are not necessarily the same fundamentals that English teachers are thinking about. Since most of the men in the employing situation are old enough to have been reared and educated with a background of certainty as to what is "right," they want young men who can use "correct" grammar, "correct" spelling and "correct" sentence structure. They do not relish any discussion, no matter how fascinating it is to the English teacher of the differences between prescriptive and descriptive grammar. They are not interested in semantics as a substitute for composition. Our concept of fundamentals is not always in accord with those of employers.

Each of us can illustrate from his own experience other instances of misunder-

* Presented at the annual meeting of ASEE, English Division, University of Illinois, June 15, 1954.

standing between those of us who teach the engineer and those who utilize his services. Fortunately a great deal of this misunderstanding has disappeared. The tone of the papers today is very different from that of twenty years ago. Certainly our understanding has increased considerably.

Significant Developments

I should like to suggest then the following ways in which this understanding is being developed:

1. One of the strong influences for the better has been the advent of the humanistic-social studies program in engineering education. You will recall that the report on engineering education in 1940 set up two stems: the scientific-technological and the humanistic-social. With the establishment of the Humanistic-Social Division of the ASEE in 1944, there was a greatly stimulated interest in the non-professional courses for engineering students. Many schools enlarged their programs, in a few cases perhaps at the expense of English courses. In most of the schools, however, I believe that the creation or renaming of courses in line with the 1940 report actually improved the status and prestige of the English teachers. The real extent of this influence will not of course be known until the study of humanistic-social programs has been completed.

2. We have had further reinforcements from the College English Association. In the past few years, CEA has been interested in the preparation of college graduates to enter business and industry. The original stimulus was to prepare English majors for occupations other than teaching. Now, however, the scope has broadened to include the non-science liberal arts courses as well.

Several English-Industry Institutes have been held to promote the understanding between people of industry and the college faculties. The latest was held last fall at the Corning Glass Center. A number of the papers that were read at that meeting were reprinted in *The Saturday Review*. You will also recall that we held a joint meeting with the CEA last year at the University of Florida. Another is to be held next week at Michigan State College. We are certainly pleased to have teachers of English in the traditional liberal arts colleges interested in preparing people for a realistic and worthwhile life even though they are English majors.

In other words, the trend is toward a greater and more realistic understanding of the needs of college graduates and the consequent adaptation of courses to that end.

3. For as long as I can remember there has always been an interest on the part of the engineering faculty in having graduates speak and write with the skill and grace expected of any college graduate. Gradually the English teachers and the engineering teachers have been getting better acquainted. Each has been winning the respect of the other.

This increased understanding has led, of course, to greater cooperation which has manifested itself in different ways. For example, in some schools there has been an increase in the advanced courses given to engineering students. Some of these are specialized courses in report writing. Not so many years ago there was a very strong conviction in engineering schools that report writing was an engineering subject that should be taught by engineering teachers. One reason why report writing courses were set up and taught by engineering faculties in some schools was that the English teachers did not respond to the occasion. In more and more schools report writing is now being taught by the English staffs. This has led to various experiments in joint efforts. One was reported at our meeting in Florida last year. Another was reported in a recent issue of the *Journal of Chemical Education*. Each of us can cite examples from our own schools.

Another joint activity has been that of withholding credit in English composition courses until graduation. Papers submitted in courses other than English are read. If the quality of writing is not that

expected of a person who should have established his right to credit, he may be required to take remedial work in English. In the schools that I know of where this plan is in operation, the stimulus came from the engineering faculty and invariably the chairman of the activity is a professor of engineering.

4. English teachers themselves are finding that there is a satisfactory career in teaching engineering and business administration students. Apparently they feel that their efforts are being appreciated. Apparently also there is an increasing emphasis upon the skill and art of teaching so that rewards of prestige, status, and salary come to those who teach as well as to those who publish.

They are seeking and receiving the equivalent of fellowships in business and industry. In the urban areas they are taking advantage of consultation work and teaching in industrial concerns. Sometimes these were undertaken purely as a means of augmenting income, but I know that in a great many cases these activities have grown into a major interest.

There are other indications that efforts are being made and that results are being obtained. I have presented these four as being the ones that are the most significant.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR IN ELECTRICAL ENGINeering on or before February 1, 1955: One familiar with electric power and electronics; preferably some industrial experience. Good opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

AN INSTRUCTOR IN ENGINEERING Drafting and Machine Design on or before February 1, 1955: One thoroughly familiar with theory and practical design who has had some industrial experience. Opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

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Teaching Positions Available are also listed on Page 417

Our Schools Can Teach Writing—If They Are Made To

By J. H. WILSON, JR.

Editorial Branch, U. S. Naval Ordnance Test Station

Our schools do not teach writing. Let's grant that to begin with. Our schools do not teach writing; they do not teach technical writing. They do not teach writing because they have not been made to. They will teach writing when they are forced to. And one very potent voice in the cry and hue that our schools begin to teach writing is that of research and development organizations employing graduates of our technical colleges or our universities.

An increasing number of industrial research and development organizations are being forced to give a course in report writing to their scientists, engineers, and technicians. Professional technical writers or editors may be brought in for the assignment, men employed in the company's writing or editorial unit; university professors may be brought in, often from some distance and at considerable expense; or, more expensive yet, a "writing consultant" may be called in. In a large organization where new men are always coming in, where men are being promoted or reassigned to jobs in which they will have to write reports, this training in report writing must be a perpetual process! While all this training is going on, management must look on and wonder whether it is really worthwhile, whether any good comes of the course, whether all the money this attempt to teach decent report writing costs is going to profit the organization. For the process of trying to teach report writing is expensive. There is first of all the cash outlay if a man is brought in on contract solely to teach a reports course; and if a man already employed is assigned to teach the course, his time, and the time of the men taking the course is lost productively. Inevitably management must ask:

"Why do we have to teach our people to write reports? Why don't our colleges teach our technical people to write reports?"

It is a fair question. Why don't our technical schools teach our technical people to write reports? Why don't engineers and scientists learn to write someplace down the line in the sixteen years or more they've been in school? It is the contention of this paper that writing is not taught in our schools because industry, commerce, business, and government, all the agencies which use the products of our schools, have not demanded that writing be taught in the schools.

The ability to write easily, quickly, and clearly is a vital part of the well-qualified technical man's equipment. At least it should be. Technical men, however, are notoriously inept at writing; so notorious that a technical man who does write with ease, with vigor, and above all, with clarity, is an anomaly. I have on my desk right now a paper by an exceedingly able mathematical physicist, sent back by a journal for "a little editorial straightening out" as "suggested" by the comment sheet. The journal bounced the article because it was unreadable, though technically acceptable. It is so garbled that no less than a complete rewriting is called for.

Whether the inability of technical men to write can or cannot be cured once they

are out of college, the finger of blame for this incompetence in writing must point to our schools, to the technical colleges which turn out our technical men.

Two Basic Problems

At least two basic problems are involved in teaching technical people to write reports—in school or after. First there is the rock-bottom problem of teaching them to write. Secondly there is the problem of teaching them to write technical reports.

To take the this-above-all problem of teaching writing. The idea is abroad, and finds support in the highest circles, that writing can no more be expected of college graduates than piano playing. Witness Barzun's article in the December 1953 *Atlantic,* "English as She Is Not Taught." Granted, if you are talking about "creative writing"; good creative writers are even fewer than good bistro pianists. But writing that is a skill, that is a mere putting down on paper of organized thoughts and ideas, experiences and experiments, can be taught to people who have enough on the ball to get through college. Writing can be taught just like we learn to talk—by practice. You can teach almost anybody who can graduate from high school to write just like you can teach them carpentry and bricklaying, chemistry and physics, arithmetic and algebra. You can teach the basic skill of writing. Any teacher of writing knows this. An editor here in the office who teaches a night class in writing said only this morning:

"One person in my class has talent. The rest I'm just teaching to write."

Once the notion is overcome that a god-given gift for writing is required to write technical reports, and it is recognized that the problem is simply that of teaching a skill, the factor of time required to teach this skill raises its hooded head. The press of a thousand other activities militates against a decent job of either teaching or learning to write technical reports in college or after.

What militates even more against adequacy in report writing is the attitude that writing is something that must be done, but really isn't too important anyway, and we shouldn't spend any more time on writing reports than the absolute minimum. There is work to be done, let's get something, anything, scribbled down and published. Despite the fact that a technical man's professional advancement depends so vitally on the papers he must publish, the general attitude toward report writing, toward all "paper work" is one of depreciation. Confronted with the fact that ours is a literate, a "paper" civilization, where in the long run the papers written and published are at least as important as anything materially produced, this looking down the nose at reporting and "paper work" is self-annihilating.

Learning to write takes time, and effort, and practice. The longer the practice, generally, the better the writing. That means that to teach writing as a skill in which high competence is expected, writing practice must begin young and continue over all the school years—grade school, high school, college.

But you can't expect grade-school or high-school students to be saddled with homework! You can't expect them to be saddled with a weekly essay through grade school, high school, and even college! Our civilization may depend on literacy—and that means writing no less than reading, since writing is the primary means of recording our culture—but the discipline of learning to write is too much to expect of our children. (And psychologists and educators are finding that grade school, high school, and college students, and adults are not much better at reading than they are at writing.)

The gist of this harangue is that writing as a skill depends upon inculcating writing habits, and writing habits can only be built up by years of conscientious effort. Learning grammar, however fundamental, will not teach you to write. Only writing will teach you to write. Why is it that so many of your technical writers and

editors are technical men who somehow always got stuck with writing reports? They got into the habit of writing! They could sit down anywhere, any time, and grind out a report. But this habit of writing should be among the habits of any qualified technical person, not as an ideal, but as a minimum qualification.

It is the practice, the building of the habit that is the important thing. Precept alone, instruction in grammar and principles of writing and organization, will not inculcate the habit of writing. Ironically—and sadly—our college people are not taught even grammar; they are not taught the principles of organization. Anyone who has taught college freshman English knows that in a class of twenty-five students he is lucky to have two or three who have a sound foundation in grammar. The pitch these days is "forget grammar!" Sure, forget grammar, ignore it completely if you like—once you know it! Just like you forget algebra when you get to calculus; you manipulate your algebra automatically. And in higher mathematics you may break the rules of algebra, but you do it consciously; you know what rules you are breaking!

Where Do the Colleges Fail?

Our colleges make a stab at teaching technical report writing. Almost every technical college of every university these days has a report writing course somewhere along the line for its engineers and science undergraduates. Almost all graduate students take a course labeled "thesis writing" or some such title. Where do the colleges fail then?

First of all, as has been pointed out, colleges have the almost impossible job of teaching these students to write before they can teach them anything called "technical report writing." Getting an engineering or science degree these days is such a rat race that it is no wonder that little time can be found for that very time-consuming discipline of practicing "technical writing."

But our colleges fall down not only in failure to teach writing, but in failure to teach at least four specific aspects of technical reporting that the technical report writer must know.

1. First of all there is the outrageously important problem of *Who is your reader?* This is a problem of all writing, for all writing is communication, and to communicate you must address yourself religiously to your reader. This addressing yourself to your reader is particularly a problem of technical writing because there are so many possible levels and combination of levels of readers. One of the most aggravating aspects of report writing to both neophyte and old timer is the keeping your reader always in mind. It is not enough that you say what you want to say; to say what you want to say is not at all what you are after in a technical report. Mere accurate reporting is not enough! What you are after is to convey to your reader the precise information and interpretation of your information that you want him to have. That means you must sit down and decide who your reader is going to be. Is he the man doing work very similar to yours, to whom you can speak almost as to your colleagues on your project? Is he the so-called technically well-informed administrator; the man a ways up the line, who is technically knowledgeable, who wants an over-all picture, but doesn't want to get buried in detail? Is he the layman, uninformed in the basic principles as well as the details of your science or technology? A chemist is a layman to an astronomer or to an archeologist.

Just who is my reader and how should I address him (or them!). To keep this question in mind is to have a report half-whipped before you start. Keeping it in mind, you can decide—though it may gripe your scientific soul and is never easy—what your approach shall be; what words you shall or shall not use, and which if you do use you should define; what data to include or not include; what your best organization shall be; what illustrations to use or not to use; what tables, if any,

should be included. Just deciding who your reader will be gets you well on the way to blocking out your report and keeps you in line once you are under way.

2. Tables are a second aspect of report writing that are either not taught at all or are glossed over in teaching technical writing in our colleges. And if there is one single phase of a report that professional technical writers and editors would pick as absorbing the most time it is tables! The difficulty in tables lies in their rigid format necessitating an equally rigid and simple logic. Relationships between the stub entries and the column headings must be clearly thought out. Grouping of items shows grouping of ideas; important items must be easily picked out and differentiated from subordinate items. In compiling a table, the author or man on the project, will often find that much fundamental thinking must be done. It is this thinking that takes the time. If you don't believe that tables require all the brain power that can be poured into them, take a look at the *Bureau of Census Manual of Tabular Presentation.*

3. Next after tables, the greatest amount of time required in putting together a report manuscript is for illustrations. Illustrating a report is not just a matter of slapping together a few graphs and charts and schematics and assorted photographs as you write the report. Illustrations are an integral part of the report, and if you can just slap in a figure, it has no business in the report. You must decide exactly what points you need illustrated. You must decide what type of figure will best illustrate this point. Once the type illustration is decided, you must decide on the details of the figure. If it is a photograph, you must get the shot from the right angle and the right distance. The photograph must show exactly what you want it to show in exactly the detail, proportion, and scale you want it to show. Nothing is harder when dealing with illustrations than to resist the temptation to slip in a figure just for "art and beauty." A technical report is not an advertising brochure.

4. Fourth of the items that are either not touched upon at all or are glossed over in university report writing courses is methods of reproduction. The report on a project reflects the project. The type of reproduction usually depends on the importance of a report, and, therefore, on the importance of the project. And whoever picks up a ditto report will assume that the project wasn't too important, not in relation to a hard-type report with the hard covers, anyway. Just as the report writer must keep his reader in mind as he writes the report, so he must keep his reader in mind as he considers the type of reproduction to give his report. He should know what kind of reproduction his report is going to get and adjust his effort accordingly. If he is writing a report to be reproduced in ditto, he need worry only about the correctness of his facts and the grossest matters of composition, tabular presentation, illustrations, and "getting to" his reader. If his report is to come out in hard type, on glossy paper, between hard covers, then it behoves him to give the report the finest possible combing over. This relation of project to report and the type reproduction to the amount of work to be put into the report is not absolute, of course; in a crush, highly important matters may be rushed into ditto. But, by and large, the report reflects the project; and the method of reproduction is an index of how much work to pour into a report.

The writer must know then what he can do with ditto, with multilith, with direct and photo offset, with hard type. He must know something about printing and commercial art and publishing processes. As a technical man, he is supposed to be literate, and to be literate in an age as much influenced by printed matter as is ours, is to know a little something about the various publishing and reproducing processes. To the degree that the technical report writer does not know the method of reproduction to be used on his report, to that degree he is unsure of what effect his report will have on the reader. And we have been at pains to point out that

his reader must at all times be uppermost in the technical report writer's mind.

Why aren't these four things—at least—taught in our technical schools? The answer is obvious. They are not taught because they are not thought important enough. Management has not got through to our technical schools—to all our schools—how important teaching writing is—specifically, how important is the teaching of technical writing.

Summary

In the press of college work that crowds the science and engineering undergraduate, forcing him nowadays to five years for his undergraduate degree, other aspects of his training are considered more important than writing. Doing and making are considered more important than writing. The feeling is—unspoken of course—that if the writing problem is ignored it will disappear. And by closing our eyes to the problem we give it that much more opportunity to get out of hand.

If a thorough job is to be done in teaching writing, a ten- or fifteen-year discipline is necessary. Writing cannot be taught by precept, only by practice. If we are really concerned to teach people to write decent technical reports, we must change our attitude toward education in writing and institute something of the Spartan regime. As nothing of the kind is in sight in grade school or high school, it is up to the colleges to give at least four or five years of practice in writing, with indoctrination in the techniques and practices of the technical report.

Until our colleges are made to institute rigorous training in writing, technical organizations will have to do what they can to train their own technical writers, doing what they can to make decent writers out of all their technical men. They must be happy if they discover and develop a few, and see to it that those discovered with adequate report-writing skill are utilized for producing the needed reports. It is unlikely that these training courses of a few weeks will uncover—for they cannot produce—sufficient number of men for report writing. Professional technical writers and editors will have to be increasingly relied upon to produce the report manuscripts and to see them into print. Such an outlook is pleasant only to technical writers and editors, who, because of the unhappy situation, find themselves increasingly in demand.

Mathematics—Engineering versus Arts

By HERMAN K. FULMER

Professor of Mathematics, Georgia Institute of Technology

Introduction

Much has been written about mathematics as a tool versus mathematics as a science, about the difference in approach of those interested in *how* as against those interested in *why*. This basic difference, inherent in the purpose of individuals, is also characteristic of many engineering colleges as opposed to arts colleges. It is the intention of this article to give some examples of this cleavage of thought, both as to individuals and institutions.

Illustrations of the Difference in Approach (Tool versus Science)

Consider the difference in approach to find real roots of $f(x) = 0$ where $f(x)$ is not restricted to algebraic functions. In general the solution will be approximate. Both the tool man and the science man approach this problem. Both look up this topic in calculus books and finally agree to try Newton's Method. Now, as is generally known, a rough statement of Newton's Method is that "If $x = c$ is an approximate solution of $f(x) = 0$, then $x = c - f(c)/f'(c)$ is a better solution." This satisfies the tool man, and so he starts on his problem. If he is able to solve it, he thinks well of Newton's Method, asks no further questions. But the science man starts asking questions at once. On what reasoning is Newton's Method based? Does it always work? How can you distinguish exceptional cases? Looking into all this, the science man finally come up with the following refinement on the original rough statement. Remember that the rough statement was that "If $x = c$ is an approximate solution of $f(x) = 0$, than $x = c - f(c)/f'(c)$ is a better solution." The refinement on this may be expressed as follows: "Assume that c is an approximate value of a root of $f(x) = 0$ in an interval between a and b which contains both c and the root. Also assume that $f'(x)$ and $f''(x)$ exist and that neither $f'(x)$ nor $f''(x)$ changes sign in a $a \leqq x \leqq b$. Then, with certain other minor restrictions it follows that $x = c - f(c)/f'(c)$ gives a better approximation than $x = c$." Thus, having satisfied himself on restrictions under which Newton's Method may be safely applied, the science man solves his problem, and he, too, thinks well of Newton's Method.

Consider the difference in approach in another basic problem—the matter of testing a given function for maximum or minimum. Both men look up references on this topic. They find that $f(x)$ has a maximum at $x = c$ if $f'(c) = 0$ and $f''(c)$ is negative; it has a minimum at $x = c$ if $f'(c) = 0$ and $f''(c)$ is positive. The tool man tries this, and it solves his problem. He concludes that it is a good rule, asks no further questions. However, the science man asks questions. Could we have a maximum or minimum without the stated conditions being true? In other words, does the converse hold? He finds that it does not. In fact, the method will not apply to so simple a case as $y = x^4$, even though there is clearly a minimum at $x = 0$. Distrusting so limited a rule, the science man does not use it at all, falls back on the more fundamental test.

Note that in both illustrations the man interested in mathematics as a tool is satisfied if the method works his problem.

The man interested in mathematics as a science is not satisfied if the method simply works his problem—he wants to know all about the method, its history, derivation, and limitations. If the method failed to work another similar problem, the tool man would probably ask what is wrong problem; the science man would ask what is wrong with the method.

Other Differences—Engineering versus Arts

To those of us teaching in technical schools, the department of mathematics in an arts college appears to have a wonderfully easy time of it. In an arts college, so it seems to us, the mathematics department is a law unto itself, enjoys almost complete freedom, neither trespasses nor is trespassed upon. Old courses may be dropped, new courses added, with few shoals in channels to delay the changes. A given course taught by A may be quite a different course when taught by B. Poorly prepared students may be passed on with no kickback in the future. Students elect the popular and interesting courses, for there are many options.

Contrast the above with the setup in the average engineering college. In the engineering college certain courses in mathematics are required for all students. These courses cannot be dropped. Also, these courses are prerequisites for other mathematics courses and for many engineering courses. It is very difficult to add new courses since the engineering curriculum is already overcrowded. It is not necessary that a course be popular or interesting. A comparison in the business world is when the seller has a monopoly of an essential. In passing we should mention here a peculiar dilemma faced by departments of mathematics in technical schools. On the one hand the demands for mathematics in all the sciences continue to increase. On the other hand science departments tend to hoard the time of their students, are unwilling to grant additional time for the study of mathematics. In other words they want mathematics, but they don't want to allot time to learn it.

Summary

We have tried to show a few of the characteristic differences in the status of mathematicians in many engineering colleges as compared with arts colleges. While it is always hazardous to predict the future, it would seem reasonable to suppose that these differences will remain and probably increase. The increasing demand for more mathematicians creates a sort of void which is sure to be filled by those who can use mathematics as a tool rather than those who know mathematics as a science. On the other hand the ancient urge to be curious, to look into the reasons for things, is certain to expand the mathematics horizon, as it has in the past.

The Role of Engineering Mechanics in Engineering Education*

By PAUL F. CHENEA

Professor of Engineering Mechanics, Purdue University

The role of engineering mechanics in engineering education is so broad and so important that I hesitate to speak on this subject in the fear that I will not be able to properly indicate its scope and thereby will underestimate its importance. It is easy to recount and discuss individual contributions of engineering mechanics to the technical education of the engineering student, but I believe that the teachers of engineering mechanics either are unaware of or completely underestimate the scope and power of the teaching vehicle with which they have been entrusted. It is a rare engineering mechanics teacher indeed who makes the most of his opportunity to contribute to the technical and professional growth of his students. I should like to indicate some of these opportunities and responsibilities with emphasis on those that are the most often overlooked and neglected. To form a framework for this discussion I would like to divide the subject matter into four categories, not because these categories are particularly distinct, but because they are convenient for my purposes here. One might entitle these divisions as follows:

1. Undergraduate Service Courses
2. Graduate Service Courses
3. Research
4. Undergraduate and Graduate Education for Research and Development Careers.

This is not their order of importance, but this sequence does offer some continuity to what I want to say.

* Presented at the Annual Meeting of A.S.E.E., Mechanics Division, University of Illinois, June, 1954.

I. *Undergraduate Service Courses*

In terms of numbers of students influenced, the undergraduate service courses offer the greatest opportunity to the teachers in the field. For various reasons we actually make little use of this opportunity, however. These courses in most curricula are the students' first real contact with scientific engineering. They can offer the student his first real glimpse of professional engineering in its highest form, but instead, they more often than not are dull and academic and appear to the student to be only a little related to his concept of the remainder of his professional education. To prove this point I should like to discuss some specific examples.

Consider the matter of being academic. How many teachers of engineering mechanics take the time to find real, practical engineering problems upon which the student can exercise his knowledge of the fundamental laws of mechanics? How many engineering mechanics teachers have actually looked at the contents of the various engineering curricula to see how the student will be expected to use mechanics in his later courses? Very few, I am afraid; other wise we would not be using the same academic examples that were in use forty years ago. Why do we have so many falling bodies that must fall, so many blocks that must slide down planes, so many strings that must be pulled over pulleys and all of this in a sterile environment frequently without atmosphere or friction? You may say that these simple problems are necessary to keep the student from being confused. I venture to say that he would be quite confused in a frie-

tionless world without atmosphere. To be sure, these approximations to physical reality are useful and necessary, but it should never be forgotten that they are approximations and their usefulness should be questioned at frequent intervals and their validity justified. The average student was born into and raised in a real physical world and he expects to practice his engineering in this same environment. It is not any wonder that he becomes disinterested in solving problems concocted on a stranger-than-fiction basis. This condemnation applies to the current textbooks with a few notable exceptions, and perhaps this is the principal "fly in the ointment." A good mechanics teacher should shake off this tendency to live in a dream world and should be at least as realistic about the engineering profession as the average student.

I hesitate to belabor this point further, but there is an additional place where we have missed the boat in this regard. The way to stimulate a student in an engineering mechanics course is to show him how the principles of engineering mechanics will be useful tools in the area of engineering in which he hopes to carve out a career. But what do we do? We proceed as though 75% of the students were going to be structural engineers and the rest of them were going into the machine design field. This may have been true forty years ago, although I doubt it, and it certainly isn't true today. I admit that these tried and true exercises found in most textbooks are good examples of the application of mechanics. But are they the ones that will generate a burning desire to learn mechanics on the part of a student of electrical, chemical, metallurgical, sanitary, or even aeronautical engineering? I don't think so. If one looks into these areas, one discovers ample examples to form a vehicle for the teaching of mechanics. Some of them are new, but most of them are similar to those of structures and machine design, but in a new disguise; and this disguise is important in generating student interest. We should select our exercises with a view towards the present division of enrollment and not tradition.

Another important responsibility of engineering mechanics undergraduate courses is that of unifying the knowledge that the student has acquired to date. All of the subject matter of mathematics, physics, etc., that forms the students' background should be put to work where applicable; indeed, I would stray off the beaten path a little to make it applicable. It is fashionable today to criticize the teachers of mathematics for not giving the engineering students greater competence in this area, but the most serious deficiency in the mathematics program rests squarely on the heads of the engineering educator; namely, they use but a tiny fraction of the mathematics to which the student has been exposed. It is no wonder that a student cannot integrate in his senior year if the last opportunity to use this tool was when he learned this technique as a sophomore. We continually cry for the mathematics teachers to adopt the "fustes with mostes" approach to their courses; then we carefully help the student "forget it." What we need is more mathematics all right, but not in the mathematics courses. We need to apply all that is now taught and on a frequent basis. In this matter mechanics offers a golden opportunity. But how many teachers of mechanics could sit down now and write out a lesson schedule for the first two years of mathematics for the engineering students as it is currently being taught at their particular institution? Not many would get half of the topics, much less the semester in which the student was exposed to topics in question. Here is an area that demands attention by the teachers and textbook-writers in the field. The above argument also applies, but to a lesser degree, to the physics courses.

There is one further point concerning the undergraduate courses that I should like to make. There is much discussion today concerning the liberal education of engineers. The fashionable approach to this problem is to turn the students over

to the liberal arts teachers as a captive audience for a few courses with instructions to "liberalize them." We engineering teachers usually turn our backs on this process as though it were none of our business. Further, we do little by example that would indicate to the student that an engineer should be liberal in his approach to his profession and life. To the student, the teacher is a model of a successful engineer and supposedly embodies and exhibits all the characteristics necessary to be a success in the engineering profession.

If we define a liberally educated man as one who has an open mind and an awareness of the society in which he lives and his part in this society, then what better vehicle exists for the liberalizing of a young man than the study of engineering that made this society possible. There isn't a single facet of modern civilization that does not have engineering as at least one of its supporting pillars. Here in our own hands we have the most obvious vehicle for creating open minded and liberal citizens; yet we insist on sending the students to the custodians of the classics to learn about the civilization which the engineering profession made possible. As an example of how we could take advantage of this opportunity that we have as teachers, we should introduce into our engineering mechanics courses some history of the field and of its founders. This need not be extensive nor dry facts. It should be based upon the real men who formulated the principles we teach, how they effected their times and how they were influenced by the society in which they lived. It should treat them as human beings playing their important role in civilization and not as godlike people without personal problems or life. A few minutes per class of the type of instruction that demonstrates the place of the present subject matter in the world of the past and today will convince the student that his teacher possesses some breadth of knowledge of society and will do much to encourage him to become a liberal-minded engineer.

II. *Graduate Service Courses*

Many engineering mechanics departments offer graduate service courses; that is, courses intended for graduate students not majoring in engineering mechanics. These courses can play an important role in the graduate programs in the professional areas. To do so, however, they must be realistic, up-to-date and closely integrated with the objectives of the professional graduate programs. These courses should be deficiency courses in the sense that they round out and supplement the graduate courses in other areas. To be healthy there should be a continual flow of subject matter out of these courses and into the professional graduate courses. The course time vacated by such a process should be filled with new applications of science to the field or the course diminished in magnitude. Above all, these courses and their subject matter should not become vested interests of the mechanics staff, for if they do, they will tend to compete with professional graduate courses and their usefulness then is questionable.

III. *Research*

The role of research in engineering mechanics departments should be somewhat different from that in the other departments of engineering, in my opinion. It should be close to the heels of pure science and have as its goal the application of more science to engineering. Again it should not, in the main, compete with research in science or in the professional engineering areas but should supplement and stimulate both of them. Consider the following examples. Engineering mechanics should do research in the computer field, not to design and build better computers and thus compete with the electrical engineers and scientists, but primarily to find new ways of using computers to solve more engineering problems efficiently and economically. We should enter the solid state field not to compete with the physicists or the physical metallurgists, but to apply this knowledge to

the everyday engineering use of materials and a better understanding of their properties. The operational analysis field should be invaded to bring its concepts and techniques to bear on the management and operations of engineering. In the latter example we are on almost virgin ground. Another example is that of the human operator. Much more information is needed about the physical capabilities of the human being if we are to better design machines that he can successfully operate. One can name many more new areas of science that need to be exploited by the engineer which are ripe for a bold attack by the workers in engineering mechanics. In addition to the above, of course, we must continue to search for new applications of the principles of classical mechanics and most important of all, encourage the professional engineering departments to do likewise. The guiding spirit of the mechanics research workers should be to supplement other research in science and engineering and to fill in the gaps where they exist.

IV. *Undergraduate and Graduate Curricula for Research and Development*

The nature of the activities in teaching and research enumerated above gives rise to a fourth very important responsibility of the teachers of engineering mechanics. What better atmosphere could exist for the education and growth of a small group of carefully chosen creative students to be the technical leaders of tomorrow's scientific engineering? Certainly, no place in the engineering educational picture can provide a more stimulating environment for nurturing the spark of genius in a gifted student than a well-balanced engineering mechanics department that is continually searching for new applications of science to engineering. It follows, therefore, that a large share of the engineering education of our most precious commodity, gifted young men and women, is a responsibility properly placed on the various engineering mechanics departments. This is a staggering responsibility, indeed, but one for which we are ideally suited. To shirk this responsibility is to refuse to shoulder our most important obligation; yet most engineering mechanics departments have only accepted this responsibility on a gradute level if at all. It is true that much can be done with more mature students on a graduate level but this is the easy part of the job. To make real progress with students of exceptional ability we must find them early and provide educational opportunities commensurate with their abilities throughout the whole span of their education.

A word or two concerning the selection of students for education in engineering mechanics is in order. Some of my more enthusiastic colleagues have advocated that all students who perform well in their freshman engineering year should automatically be placed in an engineering mechanics curricula. Nothing could be more wrong. Highly talented engineering students and highly talented engineers are needed in all walks of engineering. Only a few of the exceptional students who express a desire for careers in engineering research and development should be accepted in this program. A student in a program of this type with less than his enthusiastic approval will become a frustrated student and engineer when his career would have been spectacular in the field of his own choice. On the other hand students of only average creative and scholastic ability should not be encouraged to undertake a program in engineering mechanics. They would serve engineering and themselves best in roles where doing is more important than creative analysis and synthesis in the engineering sciences.

The curriculum on the undergraduate level deserves considerable thought. It must be far broader than the traditional field of engineering mechanics if it is to fulfill the objective of educating engineers for research and development activities. Above all, it should be remembered that the students electing this curricula will play leading roles in pioneering research activities thirty years hence. Conse-

quently the basic sciences should play a dominating part and not the engineering practice or research of today. The successful research leader thirty years from today must necessarily know much more than can be acquired in the most advanced four year, or for that matter, five, six, or eight year program today. Therefor the primary objective should be to generate lifelong scholars who can educate themselves throughout their careers. The formal university education can only provide a firm foundation for their growth. It is redundant to point out that their teachers must be outstanding scholars and authorities in their respective fields or the whole program must fail.

The curriculum must accomplish at least one additional thing; namely, it must generate an engineering point of view. There is a very real danger of graduating scientists instead of engineers from a program of this type. As Dean O'Brien has pointed out, engineering graduates must be eager to solve the problems that need to be solved in the time available. The fact that a solution is needed should provide all the motivation necessary to stimulate them to bring all of the knowledge and skill they possess to bear on the problem. This can be accomplished by using real engineering problems as vehicles for the program and by confronting the students with teachers who have the engineering point of view. The program must reek with real engineering situations mixed carefully with the pure substance of science.

As an example of an undergraduate curriculum which is pointed towards this goal, there is included in the appendix an outline of the engineering sciences program to be inagurated at Purdue University this fall. It is not perfect and undoubtedly will be modified as more experience is gained in this area. The course titles are not exact in all cases as they have occasionally been modified to make them more descriptive of the course content. Readers wishing greater detail should consult the Bulletin of the Schools of Engineering of Purdue University.

No graduate curricula is included as I feel that flexibility is essential in graduate study. Needless to say the graduate courses must be alive and current. Above all, they must stimulate the student to study the literature firsthand and think for himself. There should be guidance, to be sure, but of the provocative kind that creates a keen desire to investigate situations for himself.

Much has been said about theses. I for one do not believe that the usual Master's thesis is very fruitful. In my opinion it absorbs too much time for the benefit derived at a stage of the student's career when his breadth of knowledge still needs widening. A carefully planned project course can give the student a chance to proceed on his own initiative without shortening his Master's degree program by a third or more as is often the case with a thesis program. In fact, the need for a thesis usually grows out of the failure to conduct the graduate courses in the proper fashion. If the graduate courses spoon feed the student, then by all means this deficiency must be made up by a research program which forces the student to think for himself. If, on the other hand, the graduate courses are conducted in a manner that has the class continually searching on their own time for related information and ideas, then a thesis on the Master's level really has little additional to offer. On the doctorate level I believe that the program should be constructed completely around his dissertation and every course, if indeed any are needed, should directly contribute to this goal.

Let me say in conclusion that I believe the teachers in engineering mechanics have a responsibility and an opportunity unequalled in their history. The future of engineering education stands to benefit immeasurably if they accept the challenge.

APPENDIX

An Outline of the Curriculum for Engineering Sciences follows:

(Total credits—155⅓ semester hours)

Freshman Year

(Common to all engineering curricula)

(4) General Chemistry	(4) General Chemistry
(3) Composition	(3) American Books, Essay, Drama, Poetry, or Fiction
(2) Engineering Drawing	(2) Engineering Drawing
(0) Engineering Lectures	(5) Analytic Geometry
(5) Algebra, Trigonometry	(2⅓ to 3) Military Training
(2 to 3) Military Training	(2) Plane Surveying
(⅔) Personal Living	
(2) Welding, Heat Treating and Casting	
(18⅔ to 19⅔)	(18⅓ to 19)

Summer Session

(4) Calculus I

Note: A summer session is not required if the student has completed Calculus I during the Freshman year.

Sophomore Year

(3) Basic Mechanics I	(3) Basic Mechanics II
(1) Experimental Engineering Science I	(4) Mechanics of Solids
(3) Expository Writing	(1) Experimental Engineering Science II
(4) Calculus II	(3) Intermediate Calculus
(3) Elementary Metallurgy	(3) General Thermodynamics I
(3) Principles of Speech	(4) Basic Electrical Circuits and Electronics
(2⅓ to 3) Military Training	(2⅓ to 3) Military Training
(19⅓ to 20)	(20⅓ to 21)

Junior Year

(2) Experimental Engineering Science III	(3) Economics
(3) History of Europe since 1914 or U. S. in World Affairs	(1) Experimental Engineering Science IV
(3) Vector Analysis	(3) Basic Mechanics III
(3) Applied Theory of Complex Functions	(3) Theory of Material Properties
(3) General Thermodynamics II	(5) Ordinary and Partial Differential Equations
(3⅔) Fluid Mechanics	(3) Electromagnetic Theory
(17⅔)	(18)

Senior Year

(3) Projects in Engineering Research, Design and Development I	(4) Projects in Engineering Research Design and Development II
(0) Engineering Inspection Trip	(4) Continuum Mechanics II; Fluid Mechanics and Acoustics
(4) Continuum Mechanics I; Elasticity and Plasticity	(3) Systems Analysis and Synthesis
(3) Nuclear Engineering	(3) Elements of Democracy or International Relations
(3) Numerical Methods in Analysis	(3) Psychology for Engineers
(3) Electronics Techniques for Physical Research	(3) Non-technical Elective
(3) Non-technical Elective	
(19)	(20)

The Case Method of Teaching Mechanics*

By FERDINAND L. SINGER

Associate Professor of Engineering Mechanics, New York University

First let me state that if the title of this paper seems to imply a new and novel method of teaching mechanics, such is far from true. If such an impression was inadvertently created, I apologize for enticing you to be here today. May I start by explaining the choice of the title?

"The Case Method of Teaching Mechanics" describes a technique that has been used at New York University with gratifying success. The method is not startling in its concept and indeed may not even be new to you. It arose out of a growing need for more time to discuss the many topics that we cover in mechanics courses and at the same time retain the class participation needed for successful teaching.

The name was borrowed from the method used in teaching law. In many of those courses, the various points of law are developed in terms of the cases in which they were tried in the courts. Usually quite a few cases are assigned for study and the professor then calls on students at random to discuss any of the assigned cases.

Unfortunately, the cases are usually lengthy and require close study of the fine points of the law and, as a result, many students have time for only a cursory study of them all. In fact, during a recitation on the cases, most students were so busy refreshing their memory of the next case to be discussed that few paid much attention to the case under current discussion. One law professor of my acquaintance eliminated this difficulty by assigning one case to each student, this case being the only one for which the student was responsible and the only one on which he would be graded. Moreover, if that student were absent from the next class, the professor would recite in his stead. Thus the professor succeeded in having all students fairly alert to the class discussion instead of studying the next case.

Unfortunately this method cannot be applied verbatim to classes in mechanics. We rarely assign more than three problems at a time, and if only three particular students were assigned to recite at the next session, the vagaries of human nature would ensure very little active preparation from the rest of the class. Furthermore, the study of law and engineering are different in that while it may be possible to absorb points of law from a class discussion, engineering requires personal experience and participation beyond that of merely listening to an explanation. Nevertheless, the concept used by this law professor was so appealing that I developed a variation that I shall describe in a little while.

But first let me summarize the requirements of effective teaching. These are:

1. The learning and understanding of new principles.
2. Correlation of new with old ideas.
3. Training in orderly and logical analysis.
4. Practice in applying fundamental principles to new situations.
5. Discover student weaknesses and help them to overcome them.

This brings us to the heart of the case method of teaching which is essentially a

* Presented at the Annual Meeting of A.S.E.E., Mechanics Division, University of Illinois, June, 1954.

simple and effective manner of ensuring adequate homework preparation and its discussion. Most of us would agree this is really the keystone of successful teaching. Good textbooks and good lectures only supply the necessary background, but no one can really learn except through the personal experience of trying to apply a principle. This plus the clarification that comes from personal explanation of a topic is what really does the trick.

Let me now present the method and tell you how it is applied. It is possible that it may only be a variation of schemes that you may be using. Certainly, I am sure it can be improved. I hope it will provoke sufficient discussion to indicate such improvement.

The class is divided into three equal groups and it is the responsibility of each group to be thoroughly prepared on one of the three problems assigned. Any member of a group may expect to be called upon to recite on their group's problem but not on the others. Of course it is expected that they work out the other problems of the assignment also, but they know they need not recite on them. The recitation of other groups on the other problems enables them to fill in whatever gaps they may have encountered in trying and preparing the other problems. The essential feature of this method is that it ensures complete preparation by each student of at least one problem for each lesson.

At the start of the lesson, one student from each of the three groups is asked to put his problem on the blackboard and then to explain it. While this is done, the instructor summarizes the salient features of the next assignment, stressing those elements that he knows may cause difficulty. (It should be noted that although the students at the board miss this summary, they do so only about once in every 10 lessons.)

No grades are given for these problem recitations; only a check mark made to keep a record of who has recited. Occasionally a student appears unprepared. He then is required to submit all previous homework for inspection at the next lesson. In all cases when a student is obviously unprepared or when his quiz work is below passing, he is required to submit his homework for inspection at the next lesson. This procedure, together with random calling for a student's work, keeps the instructor informed about the quantity and quality of student work without the necessity for daily collecting and checking it.

Occasionally the student selected pleads that he knows his solution is wrong. This, to me, is even better than a perfect solution, for the chances are that others in the class have encountered the same trouble. Then I and the class have the chance to see where and why the student went astray. The student is then guided by what I hope is adroit questioning to the correct solution.

Examine Student's Presentation

The entire class thereby has the opportunity to examine the student's presentation of method and computational technique. There frequently is a lively discussion of alternative methods and the chance to show better and more accurate as well as faster methods of computation. I believe that one of the most valuable contributions of a recitation, especially where a student is thoroughly prepared and expects to recite under the case method, is the experience gained in speaking on one's feet and explaining as well as defending his presentation.

At this point, I suppose many of you are thinking that there is nothing novel in this procedure—that it is exactly what each of you do in your class recitation. Granted! The essential difference is that usually *any* student may be called upon to recite upon *any* of the assigned problems. Here he is a member of a group responsible for but *one* problem. Consequently, the instructor can reasonably expect a student to be better prepared than usual for that one problem.

In actual practice, the method has worked extremely well. I have been able to keep in close touch with all the students' work while not imposing a severe burden upon any. They like the method and cooperate fully. Examination of their work shows that generally they are up to date in all problem assignments, possibly because those they have trouble with have been fully explained in class.

One additional detail should be mentioned. The three groups are identified as group 1, group 2, and group 3. For the first assignment, the members of group 1 are responsible for the first problem of the assignment, group 2 for the second problem, and group 3 for the third one. However, the order of responsibility for assigned problems is changed with each assignment since the problems usually vary from simple to medium to maximum difficulty, and it would be manifestly unfair to keep one group responsible for only one type of problem difficulty. Therefore, the order of group responsibility changes at each lesson from 1, 2, 3, to 2, 3, 1, to 3, 1, 2, and back to 1, 2, 3.

I am sure that most of us realize that although the basic topics covered in today's courses in mechanics and strength of materials are relatively unchanged, their range of application has been greatly enlarged. Most modern textbooks provide so wide a variety of applications that an instructor who attempts to cover them all, generally has insufficient class time. If the attempt is made, they can only be discussed so briefly that confusion frequently occurs. I believe it to be better pedagogy to stress understanding of fundamental principles so firmly that the student develops confidence in his ability to apply them to any situation.

Since most modern textbooks are written in a clear prose with adequate illustrative problems, it would seem desirable to choose a method of instruction that takes full advantage of them. As I have indicated, this can be done by a limited class discussion or amplification of principles that may not be adequately covered by the text and by lively class discussions of assigned problems by which the basic principle common to all of them can be reemphazied. Incidentally, by forcing closer study of the text upon the student, we are encouraging them to develop study habits they can apply with continuing success after graduation. Most of the class time, especially if the case method of instruction is used, would then be available for class discussion of adequately prepared problems in which to emphasize the basic principle common to all the problems instead of trying to treat each problem as a special case or type.

ANNUAL MEETING—1955

Pennsylvania State University

State College, Pa.

June 20-24, 1955

ECPD Accreditation of "Fringe" Curricula

After due consideration, and after participation by several of its members in the deliberations and Interim Report of the ASEE Committee on Evaluation of Engineering Education, the ECPD Education Committee recommends as follows:

1. That the following curricula be accredited as Major Engineering Curricula: Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, Metallurgical Engineering, and Mining Engineering.

2. That the following curricula be accredited as Cognate Engineering Curricula: Aeronautical Engineering, Architectural Engineering, Agricultural Engineering, Ceramic Engineering, Geological Engineering, Geophysical Engineering, Industrial Engineering, Engineering Mathematics, Engineering Mechanics, Naval Architecture and Marine Engineering, Petroleum Engineering, Engineering Physics, Sanitary Engineering, Textile Engineering.

3. That additional Cognate Curricula be approved by ECPD after specific authorization by ECPD based on recommendations from the Education Committee.

4. That a curriculum in Engineering or in General Engineering be accredited if it meets the criteria for other major or cognate engineering curricula.

5. That any curriculum be recommended for accreditation only when it meets the following criteria in addition to those heretofore adopted by ECPD:

a. At least the equivalent of an academic year of the curriculum shall be devoted to mathematics and basic science about equally divided.

b. For Major Engineering Curricula the equivalent of approximately one academic year shall be devoted to the engineering sciences, including at least six of the following: statics; dynamics; strength of materials; fluid flow; heat flow; thermodynamics; electrical circuits, fields, and electronics; engineering materials; physical metallurgy.

c. For Cognate Engineering Curricula only the equivalent of approximately two-thirds of an academic year need be provided for coverage of the engineering sciences as listed in item 5b, provided that the remaining one-third of this equivalent academic year be devoted to other appropriate applied sciences, or basic sciences in addition to those listed in 5a.

d. Approximately the equivalent of one-half of an academic year shall be devoted to engineering analysis, design and engineering systems.

e. The curriculum shall be designed for an integrated sequential study in the scientific and engineering area. The mathematics and the basic science to be used proficiently in the work in engineering analysis, in the study of engineering systems, and in the preparation for creative design.

f. An appropriate portion of the curriculum shall be devoted to the humanistic and social studies.

6. In any case in which the Education Committee is persuaded that well-considered experimentation in engineering curricula is underway, it shall give sympathetic consideration to departures from the criteria of Sec. 5 and shall make appropriate recommendations to ECPD.

The committee recognizes that these recommendations constitute a departure from past practice in that an approach is made to quantitative criteria as to curriculum content and distribution of time.

However, the committee feels that the principal justification for curriculum designations other than those in the "major" group is to provide engineers who are versed in one or more fields of applied science but who must have an adequate background in the items covered by the criteria outlined to assure that they are in fact qualified for admission to the engineering profession. Curricula of a vocation or technical institute pattern could not qualify.

The committee continues to favor the general policy of ECPD looking toward the minimum number of specially designated curricula, and endorsing whenever practicable the utilization of options in major curricula (as Sanitary option in Civil Engineering) to designate specialization.

ASEE Catalog of Learning Aids

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Prepared by the ASEE Committee on Teaching Aids. Over 5000 teaching aids have been reviewed. The catalog lists 290 aids which are rated by the ASEE reviewing committees as the best available learning aids for engineering education. The catalog summarizes the content of each aid, recommends the course for which it is best adapted, gives details of physical size, equipment necessary, where it can be obtained, cost and other pertinent data.

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American Society for
Engineering Education,
Northwestern University,
Evanston, Illinois

Remuneration Policies of Engineering Colleges in Regard to Research and Consulting

By V. E. NEILLY

Assistant Professor of Electrical Engineering, Pennsylvania State University
Secretary, Engineering College Research Council, 1952–54

For some time the Executive Committee of the Engineering College Research Council has considered making a survey of existing institutional policies and attitudes on research by the faculties of our engineering colleges. A questionnaire covering several aspects of this work was prepared and in December of 1953, this questionnaire was sent to the representatives of each member institution of the Engineering College Research Council. This paper gives a tabulation of the answers received together with some observations by the writer. While some of the questions proved not to be completely clear or were not worded in such a way as to secure compatible answers, considerable information was obtained that should be worth while in a study by any institution or group concerned with academic research policies.

On behalf of the chairman and the executive committee of the Engineering College Research Council, I wish to thank those research and administrative officials who completed the questionnaire. Of the 103 sent out, completed questionnaires were received from 98 institutions. Many letters accompanying the returned questionnaires expressed considerable interest in the subject and in this report. To me, the fact that 98 officials took time from their busy schedules to answer these questions attests to their opinion of the importance of this work. In the letter of transmittal, the chairman assured each institutional representative that his reply would be kept confidential, that no institution would be named, and that the answers would be published only in statistical form. This report will conform to these restrictions.

This questionnaire was divided into five sections headed Consulting Work, Sponsored Research, Administration, General Work Regulations and Work Regulations for Sponsored Research. From three to six questions were asked under each heading with a total of 24 questions. This report will give the exact wording of each question followed by a tabulation of the answers received.

I. Consulting Work

A. Does your institution permit academic staff members to do consulting work for compensation in addition to their institutional salaries?
(98 answers to this question)
Yes—95
No—0
Not during academic year—3

B. If "yes" is any restriction placed on amount?
(96 answers)
Yes—74
No—22

C. If "yes" what is the restriction?
$....., % of institutional salary ....., time ....., other (explain) .....
(90 answers, however many institutions gave more than one restriction)
$100 per month—1
Percentage of institutional salary —4
20%—1

25%—1
25 to 30%—1
50%—1
Time—39
1 day per week—28
½ day per week—3
10 hours per week—1
20% of scheduled time—1
25% of scheduled time—2
Unspecified time limitation—4
Must not interfere with other duties—32
Must not compete with practicing engineers—2
Must be creative—1
Must be professional level—8
Must be approved by administrative officials—2
Each case decided on its own merits—1

D. Are there any restrictions placed on who can do consulting work?
(96 answers)
Yes—15
No—81

E. May a staff member do consulting work for extra compensation for his own institution?
(92 answers)
Yes—34
No—41
Only under special circumstances —14
This situation has never arisen—3

II. Sponsored Research

A. Does your institution permit academic staff members to do sponsored research for compensation in addition to their institutional salaries?
(95 answers)
Yes—63
No—23
Only under special circumstances —8
No policy—1

B. If "yes" is any restriction placed on amount?
(62 answers)
Yes—59
No—3

C. If "yes" what is the restriction? \$....., % of institutional salary ....., time ....., other (explain) .....
(64 answers, some institutions have more than one restriction)
\$300 per month—1
\$250 per month—2
\$150 per month—1
\$125 per month—1
\$100 per month—3
20% of institutional salary—5
25% of institutional salary—6
67% of institutional salary—1
33% of institutional salary (summer only)—3
2/9 of institutional salary (summer only)—1
Limited to the equivalent of two months' salary—1
1 day per week—5
10 hours per week—4
20 hours per week—1
6 hours per month—1
20% of scheduled time—2
25% of scheduled time—3
Time limitation (unspecified)—2
Restricted to vacation periods—10
Must not interfere with other duties—6
Permission of administrative officials required—2
Each case considered on its own merits—1
More than one day per week compensated by reduction in teaching load—1
No policy—1

D. If a teaching staff member is released, part or all of his time, for sponsored research with the research agency assuming the responsibility for this portion of his income, may he receive a higher rate of compensation for this portion of his time than he would receive for teaching?
(91 answers)
May receive a higher rate of compensation—29
May not receive a higher rate of compensation—58

May not normally receive a higher rate, but there are some exceptions—4

E. Are there any restrictions placed on who can do sponsored research?
(97 answers)
Yes—11
No—85
No policy—1

III. Administration

A. Who administers your sponsored research contract? Engineering experiment station ....., a separate group like a research foundation or research institute ....., a graduate school ....., regular business office ....., other .....
(97 answers. Some institutions listed more than one administrative agency)
Experiment station (or other integral division of Engineering school)—32
Separate group—29
Graduate school—5
Regular business office—27
Research committee—5
Coordinator or director of research—5
Individual departments—2
Industrial research division—1
Individuals—2
Engineering department—1
Dean of Engineering—1
Other (unspecified)—4

B. If a separate group, is it an integral part of your institution or is it a separate corporation?
(27 answers)
Integral part—13
Separate corporation—14

C. In the case of a separate group, is the salary paid to the research worker directly or through institutional channels?
(21 answers)
Direct—4
Through institutional channels—16
Either direct or through institutional channels—1

IV. General Work Regulations

A. What is your normal work week in hours? For teachers ....., for researchers .....
For teachers (91 answers):
40 hours—25
44 hours—10
15 contact hours—6
No stated policy—23
Twenty-seven other answers varied from a low of "10 to 12 hours" to a high of "40 to 50 hours." As there were only one or two of each different answer, it would be too awkward to attempt to classify them. Considerable confusion was found due to the lack of a definition of an "hour." Some answered simply in "hours," others in "contact hours," "credit hours," "credits," and "lecture hours."
For researchers (89 answers):
40 hours—56
44 hours—11
35 hours—4
37½ hours—2
36 hours—1
39 hours—1
45 hours—1
40 to 44 hours—1
40 to 45 hours—1
No stated policy—11

B. What is your normal work year in months? For teachers ....., for researchers .....
For teachers (97 answers):
9 months—66
10 months—11
11 months—3
12 months—6
9 and 11 months—4
9 and 12 months—4
10 and 12 months—1
9½ months—1
12 months with every third summer off—1

For researchers (94 answers):
9 months—5
10 months—1
11 months—3 *
12 months—79 *
9 or 12 months—2
10 or 12 months—3
No stated policy—1

C. What is your vacation allowance? For teachers ....., for researchers .....

The answers to this question were so varied and in so many forms that it was not considered feasible to classify them. For teachers, most gave a nine-month schedule (see B above) and listed three months' vacation. Some, however, listed a vacation schedule during the academic year. For researchers, the majority listed one month for those on a 12-month work year; however others listed two weeks, three weeks, and in many cases the vacation length depended on length of service.

D. Are all hours in excess of those mentioned above the individuals' own time or are restrictions imposed on how they may be employed?
(83 answers)
Individuals' own time—62
Restrictions are imposed—21

E1. Can annual leave (vacation time) be accumulated from one year to another? ....., for how many years? .....
(89 answers)
Leave may be accumulated—14
For 2 years—8 †
For 3 years—2
For 1½ years—1
For 7 years—1
Time limitation not given—2
Leave may not be accumulated—70
May be accumulated only in exceptional cases—5

E2. If the individual elects to work, is he paid double for his leave time?
(67 answers)
Yes—4
No—60
Extra compensation paid, but not double—2
Situation has never come up—1

F. If an individual's employment is terminated through no fault of his own, is his final check for time actually worked; or is he paid, in addition, for any leave time he has accumulated?
(86 answers)
Time actually worked—11
Accumulated leave time—70
At the option of the administration—4
No policy—1

V. Work Regulation for Sponsored Research

(The following questions pertain only to academic staff members employed on sponsored research on either a full-time or part-time basis. If they are the same as for teaching employees, please so indicate after your answer.)

A. What is your policy on sick leave?
(78 answers)
1 day per month—4
1¼ days per month—3
1½ days per month—1
2½ days per month—1
10 days per year—2
13 days per year—1
14 days per year—1
2 weeks per year—6
Up to 6 weeks—1

* Twenty-six reported 11 months; however 23 of these also listed one month's vacations. These were considered as 12-months' schedules.

† Three of these were listed as one year; however, from the wording of the question, this was taken to mean one additional year and included in the 2-year classification.

Up to 3 months—1
Up to 6 months—1
Full pay for reasonable absences —12
Unlimited—1
Practically unlimited—1
Rest of month plus one month—1
Depends on length of service—2
Policy too complex to classify—1
Full pay for 6 months; half pay thereafter—1
Till end of semester—1
Up to one year full pay less salary paid to substitute if needed—1
Each case determined on its own merits—35
Same as for teachers—46

B. What is your policy on retirement pay?
(75 answers)
State employee's retirement plan —11
Teacher's Insurance and Annuity Association—16
Social Security—3
T.I.A.A. plus Social Security—11
Institution sponsored plan—15
Institution plan plus Social Security—2
State teacher's plan—3
State teacher's plan plus Social Security—1
State employee's plan plus Social Security—2
Institution plan and/or T.I.A.A.—1
Institution plan and state plan—1
1½% of maximum salary per year's service—1
No policy—8
Same as for teachers—38

C. What is your policy on hospitalization and health insurance?
(85 answers)
State employee's plan—1
State teacher's plan—1
Optional group policies available —39
Compulsory group policies—2
Group policies (optional or compulsory not stated)—28
Institution sponsored plan—3
No policy—11
Same as for teachers—32

D. Do you have Workman's Compensation Insurance?
(93 answers)
Yes—68
No—24
Only when required by Government contract—1
Same as for teachers—20

E. For how long after the death of an employee do you pay his salary?
(87 answers)
Pay terminates on day of death—30
Continues until end of month—14
One month—8
Until day of death plus accrued leave time—4
One month plus accrued leave time —1
Two months—1
One month per year's service—1
Varies with length of service—3
Rest of the semester—1
Rest of the fiscal year—1
If single, till end of month; if married, each case considered on its own merits—1
Each case considered on its own merits—22
Same as for teachers—20

This report is intended only to present the results of the survey; the reader may make his own conclusions and compare the policies of his institution with the data presented here. It should be noted that the survey included colleges with large enrollments of engineering students and those with small enrollments; state supported and proprietary institutions; some with multi-million dollar research budgets and others with only a very few thousands. In view of the many variations, it is not surprising that so many different answers are given to questions of policy; it is perhaps more unexpected to find many areas of agreement.

Education-Industry Cooperation for Increasing Planned Faculty Employment in Industry*

By GEORGE K. DREHER

Steel Founders' Society of America

Purpose

It is the purpose of this paper to present evidence which would tend to encourage industry in various sections of the country to make increasing use of the faculties of our engineering colleges. The end result of such encouragement would reside in the improved understanding by faculty members of industrial operation, thereby making their teaching tasks more applicable to the actual needs of industry and, even more than that, to bring into action the vast amount of engineering and scientific knowledge possessed by the higher level faculty members of our engineering colleges.

Method

In so doing, we have endeavored to determine the following by means of a survey addressed to educators, selected industry personnel and engineering college administrators. The specific objectives of this survey are best defined by the following list:

a) The scope of faculty employment by industry.
b) The purpose of such employment.
c) The time during the year when such employment occurs.
d) To identify benefits to faculty and industry alike.
e) To identify secondary benefits to students and society in general.
f) To recommend a general policy to foster and guide a possible program.

Reservations

Certain reservations must be kept in mind. The survey was restricted to a relatively small number of schools, and the same can be said for administrators and industry personnel alike. It is our hope that the material presented hereafter will represent a sampling which will be sufficient to identify the general trend in either the employment of faculty members by industry or the role of individual companies and industries as clients of the engineering faculty. By no stretch of the imagination can this paper be regarded as a scientific analysis. It is, however, of sufficient value to be an encouragement and an example to all concerned.

Faculty Questionnaire

In the questionnaire addressed to faculty members, several questions were asked which are analyzed as follows:

One hundred seventy-eight members replied, which break down to ten per cent in the Instructor group, thirty-one per cent assistant professors, twenty-four per cent Associate professors, and thirty-five per cent full professors. Of those replying, only nine did not have prior employment in industry in any form.

Thirty-nine per cent of those replying engaged in summertime activity only; five per cent functioned with industry during leave of absence; thirteen per cent were on part-time employment; thirty-

* Presented by John Gammell, Allis-Chalmers Manufacturing Co., at the Meeting of Institutional Representatives, ECAC, University of Illinois, June 18, 1954.

eight per cent acted as consultants on a continuous basis; and five per cent did not answer the question.

In answer to the question as to the reason for such industrial service, thirty-five per cent replied that they had hoped to gain experience in their particular field; sixteen per cent identified their service as a means of earning money; six per cent functioned as teachers in industry. Another six per cent acted as research aids; five per cent worked as analysts; twenty-one per cent were assigned to a specific problem; six per cent functioned as project directors; three per cent were employed in the research field directing others; and two per cent attended short-term seminars conducted by various firms.

Remuneration for these services found that twenty-two per cent of those employed by industry were paid on an hourly basis, with thirty-four per cent on salary. Twenty-one per cent were paid on a per diem rate, and fourteen per cent functioned under contract arrangement. Nine per cent did not answer the question. The per diem and contract groups had their expenses paid as well, and the same is true for a smaller proportion of the salary contingent.

These men reported to various individuals within their respective corporations during the time of their employment or service. Only one per cent reported to foremen, and another four per cent to superintendents. We believe that this is rather significant, as the balance of the men so employed made their reports to the higher echelon in the business world. We tabulate these as follows:

To Department Head	18%
To Plant Manager	3%
To Manufacturing Mgr.	2%
To General Manager	7%
To Project Engineer	13%
To Chief Engineer	18%
To Research Director	12%
To Vice President	9%
To President	13%

Reports are made in a variety of ways. The survey shows that twenty-four per cent of them were made verbally to their superiors, and forty-one per cent were in written form. Thirteen per cent were illustrated in various manners, and seventeen per cent did most of their reporting by means of drawings. Four per cent used models to present their results, and only one per cent in patents. It must be borne in mind, however, that much of the work done by others perhaps led to, or was a part of, research and development which could, and probably did, lead to a greater number of patents over a longer period of time.

The policy covering patents granted varied, but for the most part they belonged to the company.

Several other points grew out of this particular question. In some cases, the same policy existed as for other employees. In others, the rights were granted to the government. A few companies took the patent and shared the royalty with the faculty member so employed.

In one instance, the patent was granted in the name of the faculty member, but the rights were held by the company. In others, patents were signed over by virtue of prior contract. Four responses indicated that the faculty member received a bonus or shared in the benefits of the patent.

Appendix "A" lists the colleges whose faculties have responded to this questionnaire. Appendix "B" shows the nature of the industries and professions employing or engaging faculty members, and Appendix "C" lists the companies for whom they served.

College Administrator Questionnaire

Fourteen engineering college administrators answered a parallel questionnaire about the policies and activities of their own colleges. Running throughout these replies was the general statement that

most relationships of their faculties with industry were okay if they did not interfere with school obligations, such as committee assignments or research assigned by school authorities.

The majority of these schools also reported that over 50% of their faculty engaged in some sort of paid summer employment or professional work. The reverse was true of the college year activities, where only two schools indicated that over 50% of their faculty engaged in some work. The remainder reported less than half who had part-time or consulting activity during the regular school months.

The regulations covering such work quite naturally were very limited, as far as the summer activity is concerned, except where the faculty member was assigned to summer school or administrative work during that period. One school stated that they insisted that their faculty men have at least one month's vacation.

Written requests and subsequent permission were needed in the majority of cases for leaves of absence. Most of the schools have a sabbatic leave granted for one term after a specified length of service; a few indicated that no regulations had been set up, and each case was considered on its merits. These leaves are restricted, depending on school policy, to anywhere from six months to one year maximum time.

Part-time school year activities were divided up between written requests and permission with an open policy, as long as it did not interfere with school obligations. Strangely enough, an equal number stated that no firm regulations existed.

Essentially the same general practice applied as far as consulting and professional services were concerned, although in a greater number of cases more freedom was allowed the faculty member, as long as it did not interfere. Two of the colleges reporting stated that only a specified number of hours per week were permissible.

Where on-campus services were required which involved the use of laboratories and equipment, considerable variation was recorded. It appears that, where the faculty member is assigned a research project by the school, his teaching load is correspondingly reduced to permit such activity. At other schools, any on-campus activity is a matter of contract between the college and the particular company or industry involved. At others, a fee is fixed for the project in mind, which the faculty member must include as a part of his fee to the client. It is also evident that considerable discretion as to what this overhead and laboratory fee should be resides in the heads of the departments in many institutions. Other schools apply fixed overheads up to as high as 40% of the direct time involved, and others have a flat 33⅓% charge of the fee earned by the consultant.

Publication rights for college-sponsored work are generally given to the individual. Two schools stated that it was the property of the school in all cases. It is also evident that the school expected such publications to bear the name of the university and to give due credit to the school and other faculty members for the assistance rendered.

Patents presented a rather mixed pattern. If the project was not subsidized or directed by the college, the patent could belong to the individual. Where the company has sponsored the research, the company gets the patent, but the college reserves the right to use the same in their own operation. One college indicated that, if college facilities were used, the resulting patent belonged to the school; in others, the royalties were to be divided among the individual, the school and the company.

The results of this section of the survey would indicate that no definite pattern

seems to exist, with the possible exception of the statement made at the beginning—namely, that on-campus and off-campus activities were permissible if they did not interfere with their teaching duties.

Industry Questionnaire

Seventeen industries responded to another questionnaire concerning their use of faculty talent, both as employees as well as for professional services.

Some of the general scientific and engineering fields identified by them are rather unusual. In addition to the regular engineering and scientific types of service, these firms also indicated that psychology, physiology and pure mechanics were important to them. Other fields included automatic controls, chemistry and metallurgy, research, development, design, power generation, general construction and aircraft.

For the most part, these firms specified the employment of professors, assistant professors, associate professors and instructors in that sequence of relative importance. Strangely enough, this employment was about one-third during the summer, and the other two-thirds on a part-time or consulting basis during the whole year.

These companies also indicated that most of these men were engaged for work on specific problems, or as an analyst or research aid. Lesser numbers were employed purely as an opportunity for the man to gain experience, and a few were employed as teachers for plant programs.

Remuneration was generally on a salary basis, although contract and per diem were identified as a frequent mechanism for this purpose.

These companies also specified that for the most part these faculty members reported to Department heads, followed closely by the Chief Engineer or the Research Director. Lesser numbers reported to the President, Vice President, or the Superintendent. Only occasional cases where Manufacturing Manager, General Manager, or the Plant Manager came into the picture were noted.

Reports were equally divided between verbal and written, and in about two-thirds of the cases all patent rights are the property of the company. In the balance of the cases, some division or bonus arrangement was in effect.

Appendix "D" lists the names of the companies replying to the questionnaire.

Conclusions

We believe that this paper, which very briefly presents the wealth of material contained in the survey replies, does accomplish its initial purpose—namely, to serve as an encouragement and an example to both industries and colleges, and faculty members as well. It not only applies to summer employment, but even more strongly (as the survey results show) to the year-round use of the scientific and engineering ability of faculty members as consultants, analysts and research men for a wide variety of industries.

At the moment, industry is using faculty members primarily for the last-mentioned purposes. There is some evidence that summer-time employment for instructors, and even for professors, is being conducted as a means of acquainting these men with developments in industry and making them aware of the problems which the students will encounter as they graduate from engineering school.

It is evident from the survey, too, that considerable benefit must be attained through the use of this talent by those firms engaging their services. This factor alone should encourage industries in other parts of the country, particularly in the developing south and west, to avail themselves of the abilities within their territory. The wide assortment of indus-

trial activity identified in Appendix "B" leaves almost no loophole as far as industrial coverage is concerned.

Some negative conclusions are also evident in that the policies in regard to patents in industry, as well as on college campuses, vary from the extreme of being completely open to very rigid and thoroughly controlled assignments.

Policies concerning faculty employment have an equally wide-spread pattern within the universities. Some schools have developed very stringent policies on this matter, and others again are completely open or subject to individual consideration.

About the only firm policy that might grow out of the survey, as far as the universities are concerned, is that generally the faculty is permitted to engage in consulting and other outside activity as long as it does not interfere with their teaching load, assignments to committees, and other campus duties by the university administrators, or assignments to direct research work where contracts for same are written with the university rather than with the individual.

The only firm conclusion from the industry questionnaire seemed to reside in the fact that many firms are making extensive use of the scientific and engineering talent possessed by the faculty members. The manner in which this talent is used, paid, and integrated into the company's activity does not seem to develo into a definite pattern at this time.

We must state also that considerabl material is contained in the survey repli which has not been incorporated into thi paper. We believe that these replies of fer material for further development an discussion, and we do recommend tha further consideration be given them i future meetings of the Relations Wit Industry Division.

We are not prepared at this time t suggest that perhaps policies for both in dustry, as well as colleges, could logicall be formed or, if done, that such would b of any concrete value. It is possible however, that some over-all recommenda tions could be made. It seems logica that industries will seek out those engi neering colleges whose policies are mos appropriate and adapt themselves more thoroughly to the operations of the given company. We believe this would be par ticularly true of the medium to small firms who would shy away from rigi college policies and contracts and would tend to seek out more flexible arrange ments at some other university. In other words, it is possible to become too strict in the administration of this faculty em ployment by industry program on both the industry and college side.

It is hoped that this paper can serv as an eye-opener to some industrial firms and thereby help spread this particula phase of college-industry activity.

APPENDIX "A"

Engineering Colleges Represented in This Survey

University of Alabama
University of California—Los Angeles
Carnegie Tech
Case Institute of Technology
University of Cincinnati
Cornell University
University of Delaware
University of Detroit
State University of Iowa
Lafayette College
Louisiana State University
Michigan State College
Missouri School of Mines
University of Missouri
Northwestern University
Pennsylvania State College
Purdue University
University of Texas
Virginia Polytechnic Institute
University of Wisconsin

APPENDIX "B"

Nature of Industries and Professions Served by Responding Faculty Members

AEC Research
Air Conditioning and Heating
Aircraft
Architectural
Automotive
Ceramic
Chemical
Clothing
Coal
Construction
Consultant
Design
Diesel
Electrical
Electronics
Engineering, Civil
Engineering, General
Engineering Research
Farm Equipment
Foundry
Geophysical
Heating and Ventilating
Heat Treatment
Hydraulic Eng.
Industries with Trade Waste Problems
Instructor
Insurance Companies
Legal
Machine Design
Machine Tools
Magnesium Producer
Management Consultant
Manufacturing
Metals
Minerals
Naval Ordnance
Ordnance
Paper Industry
Petrochemical
Petroleum and Oil
Pharmaceutical
Plastics
Powder Metallurgy
Power
Power Plant
Precision Casting
Printing
Production
Public Utilities
Railroads
Refrigeration
Research and Design
Research (Only)
Shipyard
Steel
Tool
U. S. Govt.
Utility
Water Treatment
Wood Conversion
Writing in Business

APPENDIX "C"

Companies Reported by Faculty Members as Their Employers or Clients

A C Spark Plug
A.E.C.
Am. Bridge Div. of U. S. Steel
Am. Flexible Coupling Co.
Anaconda
F. N. Arbaugh Mfg. Co.
Babcock & Wilcox Boiler Co.
Babcock & Wilson Co.
Bell Labs.
Bethlehem Steel
Biochemical Research Foundation
Black & Veatch Co.
Blue Ridge Overall Co.
Boeing Airplane Co.
Bristol Laboratories, Inc.
Brown & Sharpe
Burlington Instrument Co.
Chance Vought Aircraft
Chicago Pump Co.
Chippewa Flambeau Improvement Co.
Chrysler Corporation
Cleveland Electric Illuminating Co.
Consumer Power Co.
Curtiss-Wright
Cutler Hammer, Inc.
John Deere Plow Co.
Detroit Edison Co.
City of Detroit Lakes, Minn.
Douglas Aircraft
Dow Chemical Co.
E. I. duPont & Co.
City of East Lansing

Eixie Pine Products
Ethyl Corporation
Fiberglass
Foote Mineral Co.
Foster Eng. Co.
G.M. Foster Co.
General Development Co.
General Electric
General Metals Powder Co.
General Motors
Govt. Research Lab.
Grede Foundries
Haller Raymond & Brown, Inc.
Harvard Underwater Sand Lab.
Haynes Stellite Co.
Hydraulic Press
IBM
Jackson & Church
Jackson Industries, Inc.
Kaydon Eng. Corp.
Kish Engineering Corp.
Knapper-Tibbetts-Abbott Engr. Co.
Kohler Co.
Kold-Hold Mfg. Co.
Liverman & Samulson Architects
Lockheed Aircraft
Maxwell Bridge Co.
Missouri Highway Dept.
National Iron Co.
National Lead Co.
Northwestern R. R. Co.
Oak Ridge Lab.
Ohio Malleable
Owens-Corning Fiberglass
Penna. Power & Light Co.
Phila. Electric Co.
Pure Oil Co.
RCA
Reo Motors
Rocky Mountain Hydraulic Lab.
Russell & Axon Consulting Engrs.
Rust Engineering
Sears Roebuck
Geo. G. Sharp, N.A.
Slinger Foundry
Eberle M. Smith Assoc.
S & S Machinery
Standard Oil
Oliver M. Stone, Architect
Texas Foundries
Textile Machinery Works
Tipton Electric & Water Co.
TVA
Union Sulphur Co.
U.S. Air Corp.
U.S. Bureau of Mines
U.S. Bureau of Reclamation
U.S. Engineer Corp.
U.S. Maritime Service
U.S. Naval Gun Factory
U.S. Navy Electronics Lab
U.S. Navy Underwater Sand Lab
U.S. Steel
The Western Company
Western Electric
Westinghouse Electric
York Corporation

APPENDIX "D"

Companies Replying to Questionnaire

Allis-Chalmers Mfg. Co.
American Tel. & Tel. Co.
Bell Telephone Laboratories, Inc.
Boeing Airplane Company
Caterpillar Tractor Co.
Curtiss-Wright Corp.
Detroit Edison Co.
E. I. duPont
Eastman Kodak Company
General Electric Co.
International Harvester Co.
International Nickel Co., Inc.
Minneapolis-Honeywell Reg. Co.
Minnesota Mining & Mfg. Co.
Monsanto Chemical Company
Research Laboratories Div. of General Motors Corp.
Standard Oil Co., Ohio
Westinghouse Electric Corp.
Anonymous

Engineers Joint Council

For the first time in its history, Engineers Joint Council, composed of eight major engineering societies with a total membership of 170,000, will hold a General Assembly and a banquet. A day-long program of discussions of subjects important to the engineering profession will take place Jan. 21, 1955, in the Hotel Statler, New York City. While a broad variety of topics will be taken up by committees and speakers, the basic theme will be the increase of unity in the engineering profession. The comprehensive proceedings will include addresses at luncheon and dinner by nationally known figures.

Discussions will deal with the problem of engineering manpower shortage, employment conditions as they affect engineers, the national water policy which has occupied the Council's attention for several years, activities in specialized areas of engineering such as in the industrial and peacetime phases of nuclear development, and finally, the future usefulness of EJC to affiliate and associate societies.

Thorndike Saville, Dean of Engineering at New York University, is President of the Council, which will install new officers the evening of Jan. 21

Objectives of Engineers Joint Council include advancement of the general welfare of mankind through the available resources and creative ability of the engineering profession; cooperation of the branches of the profession; advancement of the science and profession of engineering; development of sound public policies in national and international affairs wherein the profession can be helpful through the services of the members of the profession.

To achieve these objectives, the Council acts as an advisory and coordinating agency to seek and study matters of mutual interest to the constituent societies in instances in which these societies desire such joint representation; it administers, on behalf of the engineering profession, activities authorized by a majority of the constituent societies.

Engineers Joint Council operates through twenty-three committees composed of eminent engineers who volunteer their services through their own Society. The activities of these committees are coordinated by the EJC Board of Directors, composed of members of the Boards of the Constituent Societies.

EJC's first General Assembly will close with a banquet to be addressed by Donald A. Quarles, Assistant Secretary of Defense for Research and Development and past president of AIEE.

Minutes of Executive Board*

A meeting of the Executive Board of the ASEE was held in the Hotel Alms in Cincinnati, Ohio on Wednesday, October 27, 1954 at 8:30 A.M. Those present included: N. W. Dougherty, *President*; W. L. Everitt, L. J. Lassalle, B. R. Teare, Jr., and H. K. Work, *Vice Presidents*; G. W. Farnham, *Treasurer*; A. B. Bronwell, *Secretary*; C. E. Watson, *Assistant Secretary*; and M. Strohm.

Report of the Secretary

The Secretary reported on the possibility of his being invited to take the Presidency at Worcester Polytechnic Institute beginning February 1. The Executive Board recommended that a letter be sent to the deans of engineering colleges asking for suggestions for a successor as Secretary of the Society. The Board will meet on November 15 in Washington to narrow down the field of selection and establish a procedure for the eventual choice of Secretary. It was recommended that the matter of location of the ASEE headquarters office be deferred until the new Secretary is found.

The Secretary stated that he would work with the new Secretary throughout the months ahead in effecting a smooth transition and will assist him in every way possible at the Annual Meeting. The commencement activities at WPI terminate on Sunday prior to the Annual Meeting and it will therefore not be possible for him to be present until Monday at the beginning of the Annual Meeting.

Report of the Treasurer

The quarterly report of the Treasurer was presented and accepted. The dues income is approximately $3000 ahead of last year's income for the corresponding period, indicating a probable increase of about $7000 for the year resulting from the change in dues status. The expense items are in line with those of the previous year.

The Treasurer reported that $25,000 of the Society funds had been invested in New York, Chicago and Evanston banks and that $15,000 had been invested in Series K bonds. These funds had been previously lying idle in the checking account. A portion of these funds has been collected from outside agencies and is earmarked for special projects which the Society has in progress.

The Executive Board voted to waive the institutional dues of Northwestern University in view of the space and facilities which are provided for the headquarters office.

Summer Institute Proposal

This item is summarized in the Minutes of the General Council Meeting.

Graduate Study Proposal

A preliminary report of the ad hoc Graduate Committee, appointed to study the possibility of undertaking a comprehensive investigation of the curricular goals and objectives in graduate study, was presented for discussion. The ad hoc Committee felt that the Manual on Graduate Study prepared by a Committee under the chairmanship of Dean Grinter several years ago, provides effective coverage of some of the general policies of graduate study. However, the Committee felt that it would be desirable to conduct studies on specific problems in graduate education. The Committee has not as yet formulated a specific plan as to how such studies should proceed.

Several of the Executive Board members expressed the opinion that a thorough and objective study which would not regard the traditions of the past as

being inviolable, but rather which would challenge some of these traditions would be highly desirable.

Teaching Aids Bulletin

This item is summarized in the minutes of the General Council Meeting.

Evaluation of Engineering Education

The Secretary reviewed the financial status of the Committee, stating that the fund for this study had a balance of less than $5000. Additional financial support seems possible from several different sources.

Publication Policy

The Secretary pointed out that the various Division publications of the Society are providing a vital service in bringing to members of the Society information which could be of direct service to them in their teaching work. He raised the question of whether or not the Society should provide financial assistance to make it possible for the Divisions to expand their publications. The alternative would be to publish more papers of direct value to the teacher in the classroom in the JOURNAL OF ENGINEERING EDUCATION. The latter procedure would get a wider audience, but would be more costly. In general, the *Journal* has tried to carry articles of interest to the major Divisions of the Society, although articles of a highly specialized character have usually been avoided because of limited interest.

It was pointed out that the section entitled "Teaching Tips" in the *Journal* includes papers helpful to teachers. The Board members expressed the opinion that an attempt should be made to strengthen the JOURNAL OF ENGINEERING EDUCATION by including more papers of direct value to the teacher in the classroom.

ASEE Branch at Clarkson College

The application for a Branch of ASEE at Clarkson College of Technology was unanimously approved by the Board.

International Science Foundation

The ASEE Executive Board voted to decline the invitation of the International Science Foundation to become a member. This organization is attempting to set up centers throughout the country for scientists and engineers who visit this country from foreign countries. The Board believed that this service is already being provided by the U.S. State Department and by engineering colleges and other organizations.

Annual Meeting

The Secretary stated that the Local Committee at Pennsylvania State University has been organized and is effectively planning ahead on the Annual Meeting. A meeting of the Committee on the Annual Meeting was scheduled for Friday morning following the Executive Board meeting.

Headquarters office will mail out to the Divisions and Committees of the Society within two weeks a tentative schedule for the Annual Meeting for this year.

A letter from Mr. Gammell, past Chairman of the Division of Relations with Industry, supporting the recommendation of Dean Downie-Smith to the effect that the Society hold a principal meeting on the general subject on "How Does the United States Measure up to the Rest of the World in Scientific-Technological Education" was discussed. Dr. Work stated that ECRC would like to consider a joint meeting with the Relations with Industry Division dealing with this subject.

Summer Schools

The Executive Board voted to approve tentatively the request of the English Division for a Summer School, but urged that the Division prepare an outline and a budget as soon as possible.

A Summer School in Chemical Engineering was proposed last spring, but no specific outline or budget has been received. The Secretary will again contact the Chairman of the Division in this regard.

Section Business

Vice President Teare reported that the Upper New York Section would like to have the University of Toronto affiliated with its Section. The Board voted approval, providing that this meets with the wishes of the members in Toronto.

The question was raised as to whether or not the Section Manual, which was prepared by Dr. Armsby several years ago, should not be printed and distributed to Sections to be used as a guide in the operation of their Section meetings. This manual supplies helpful information on the operation of Section meetings. It was recommended that copies of the manual be sent to the Sections with the understanding that this is merely suggested material.

Questionnaire on Nuclear Science Education

A request to have ASEE send out under its sponsorship a questionnaire to get information on courses offered in nuclear science was discussed. The Executive Board believed that the questionnaire might be sent out by the ASEE Committee on Atomic Energy Education if they deem it advisable, but that it should not be sent out by ASEE Headquarters, since this would establish a precedent whereby ASEE might feel obligated to send out similar questionnaires in other educational areas. The Board believed that the burden of questionnaires raises very difficult problems and in general should be minimized, although there are certain areas where information is highly desirable.

Honorary Membership

The Committee on Honorary Membership has asked the Executive Board for instructions on several matters relating to the qualifications of individuals for Honorary Membership in ASEE. The Executive Board suggested that the Committee prepare its own recommendations for consideration by the Board. One of the principal problems is whether or not a person to be eligible for Honorary Membership should have had active participation in ASEE. It is conceivable that the Society might want to confer Honorary Membership on some outstanding individual who might not even be a member of the Society. The Executive Board felt that membership in ASEE should be a prerequisite and that responsible participation in the Society should be given a great deal of weight, if not be made a requirement of eligibility.

The Next Executive Board Meeting

The next Executive Board meeting will be held at the time of the Land Grant College Association meeting on Monday morning, November 15.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Minutes of the General Council Meeting*

A meeting of the General Council of the American Society for Engineering Education was held on October 27, 1954 at 6:30 P.M. at the Hotel Alms in Cincinnati, Ohio. Those present included: N. W. Dougherty, *President*; W. L. Everitt, L. J. Lassalle, B. R. Teare, H. K. Work, *Vice Presidents*; A. B. Bronwell, *Secretary*; G. W. Farnham, *Treasurer*; C. A. Brown, W. L. Collins, R. H. Driftmier, R. F. Eisenberg, L. E. Grinter, F. F. Groseclose, K. L. Holderman, H. K. Justice, G. A. Marston, H. C. Messinger, R. S. Paffenbarger, N. A. Parker, H. L. Rodes, L. A. Rose, T. Saville, R. H. Schoonover, R. J. Seeger, P. E. Soneson, L. E. Stout, N. D. Thomas, R. W. Van Houten, R. E. Vivian, K. F. Wendt, W. R. Woolrich; F. M. Dawson, C. W. Muhlenbruch, J. C. Reed, (invited guests); M. E. Strohm.

Report of the Secretary

The Secretary reported that the planning for the Annual Meeting was underway and that the local committee at Pennsylvania State University has been organized and is making substantial progress. This will be the centennial year of Pennsylvania State University, and the Annual Meeting of ASEE will be one of the highlights of the activities of the University. The Executive Board has recommended that there be three General Sessions, scheduled for Tuesday, Wednesday and Thursday mornings. One of these will be a General Session of the Society, which will feature a welcoming address, the ASEE President's address, a program dealing with the progress of the humanistic-social research project, and a discussion of the final report on Evaluation of Engineering Education. One of the General Sessions will deal with the subject "Research and Engineering Education." The other General Session, sponsored by ECAC, will deal with some subject of widespread interest to the Society membership at large.

A General Session will also be held on Monday afternoon at which time there will be reports on various principal projects of the Society. Conferences of Divisions and Committees will be scheduled concurrently with the Monday afternoon General Session.

The Secretary stated that the Divisions of the Society had been urged to hold joint meetings wherever possible.

Report of the Treasurer

The Treasurer reported on the investment of Society funds. This item is summarized in the minutes of the Executive Board meeting.

Summer Institutes—1954

Vice President Teare reported on the Summer Institute on Solid State Physics in Engineering Education which was held jointly by the University of Illinois and Carnegie Institute. Approximately 120 people attended the Carnegie conference. This was highly successful and evoked widespread discussion on educational aspects of this rapidly developing field, particularly in the possibility of getting a more scientific basis for courses in materials. The proceedings of this conference will be published in book form by John Wiley and Sons.

The Secretary reported on the Summer Institute on Nuclear Science in Engineering Education, sponsored jointly by Columbia University and Northwestern University. He stated that the conference was attended by 110 people. This conference agreed with the Carnegie conference in urging that courses in modern physics be offered either as elective or re-

quired courses in the engineering curricula. It also made certain recommendations for treatment of nuclear science and nuclear engineering material. A report of this conference will be published in the *Journal*. The proceedings of the conference will be published either in book form or as a part of the JOURNAL OF ENGINEERING EDUCATION, subsidized by funds available for the conference. The Society owes a deep debt of gratitude to the National Science Foundation for the financial support which it provided for these two Summer Institutes. The great success of these two Summer Institutes has pointed to a new kind of ASEE operation in exploring frontier areas for educational purposes.

Proposals for Future Summer Institutes and Conferences

Dr. Seeger, Chairman of the ASEE Physics Division, presented the recommendations of a Sub-Committee consisting of G. G. Brown, A. B. Bronwell and himself, relating to Summer Institutes for the coming year. Four specific proposals were presented. One of these provides for a Summer Institute in Thermodynamics to be sponsored jointly by Purdue University and Pennsylvania State University. This Summer Institute will deal with the different viewpoints on the subject of Thermodynamics, as held by physicists, chemists, chemical engineers and mechanical engineers. The General Council approved this Summer Institute proposal and also the request for funds from the National Science Foundation.

The second proposal was for a conference on the integration and correlation of subject matter in mechanics sequences in the engineering curricula. This would include re-evaluation of the instructional material in the physics and engineering courses. It was proposed that this Summer Institute be held at New York University. The conference would bring together about 20 to 25 leading authorities in physics and engineering mechanics instruction. The results of the conference would provide program material for the Physics and Engineering Mechanics Division meetings at the ASEE Annual Meeting at Pennsylvania State University. The General Council approved this conference and recommended that Professor Singer, Chairman of the Engineering Mechanics Division, serve as Chairman of its Planning Committee. The proposal to solicit funds from the National Science Foundation for travel expenses of participants was approved.

A proposal from Lehigh University to hold a similar conference on Electricity and Magnetism, bringing together leading educational authorities of this subject to discuss the integration and correlation of instructional material in electricity and magnetism sequences, as taught in physics and engineering courses, was also approved, and permission was granted to seek funds from the National Science Foundation.

The ad Hoc Committee considering the Summer Institute Proposals also recommended that a Summer Institute be held sometime during 1956 dealing with aspects of "Theoretical Engineering." This conference would explore advanced mathematical methods used in various fields of engineering and physics in an attempt to develop unifying themes and methods of approach which will stress the similarities in mathematical methods. The Council recommended that the Secretary approach Dr. Lindvall at California Institute of Technology to determine whether or not he would be interested in serving as Chairman of the Planning Committee to prepare a proposal. It was suggested that the closed session might be held at California Institute of Technology and the open session at the University of Michigan.

Humanistic-Social Research Project

The progress of the Humanistic-Social Research Project was reviewed. The field committee is now investigating humanistic-social courses and instructional meth-

ods in engineering colleges throughout the country. The director of the project, Dr. George Gullette, is making a tour of the country to examine in detail some of the more successful projects. This material will be presented to the Humanistic-Social Committee for their analysis. This Committee will add its own recommendations of profitable avenues of experimentation. Dr. Edwin S. Burdell is Chairman of the Humanistic-Social Research Committee.

Evaluation of Engineering Education

Dr. Grinter, Chairman of the Committee on Evaluation of Engineering Education, reported that the Interim Report had been very favorably received by educators and industrial people alike and that over 8000 copies have been sold during the five months since the Annual Meeting. This report has been of great help to the ECPD Committee on Education in their their accreditation policies. The General Electric Company sent out approximately 500 copies to leaders in industry. The industrial comments will be reviewed by the Evaluation Committee.

Dr. Grinter mentioned that the civil engineers, in general, were most critical of the report, insisting that young engineering graduates should be educated in such a way as to be able to earn their way during the first year in industry. This would require a considerably greater emphasis on the practice of engineering than is recommended in the Interim Report.

Dr. Grinter mentioned that comments received indicated that considerably more attention should be devoted in the report to the humanistic-social portion of the curricula and also to graduate study. While these are being undertaken as separate studies of the Society, still it was felt that the Committee on Evaluation of Engineering Education should express its own views in these areas. The Evaluation Committee will meet at the Land Grant College Association meeting in November. A meeting of the full committee will probably be held during the month of January or February to complete the recommendations for the final report.

EUSEC

Dean Saville reported that the second international conference of European nations, U.S. and Canada dealing with engineering education in Switzerland met in September. This conference known as EUSEC brought together a wide diversity of viewpoints. Dr. Grinter reported that the Interim Report on Evaluation of Engineering Education had evoked great interest among the delegates present at the conference. He also recommended that invitations be sent to all of the delegates of the EUSEC Conference to attend the ASEE Annual Meeting at Pennsylvania State University in June, 1955.

Graduate Study Project

This item is summarized in the minutes of the Executive Board.

Curricular Specializations

A suggestion has been made that the Society make a comprehensive study of curricular specializations in engineering education. This study would examine from a fresh point of view the structure of engineering curricula and particularly the advantages and disadvantages of retaining the present curricular specializations of electrical, chemical, mechanical, and civil engineering. It would examine various means of achieving greater unity in engineering education and explore the advantages and disadvantages of each. The desirability of such a project had been studied previously by the Executive Board and the Board recommended that an ad hoc committee be appointed to look into the matter. Since the ad hoc Committee met after the Council Meeting, a specific proposal was not available, but it will be referred to the Council at a future meeting.

Learning Aids Bulletin

Professor Carl Muhlenbruch presented a printer's model of the *Learning Aids*

Bulletin, which will be available about the end of December. He stated that over 5000 visual aids were reviewed and that the bulletin describes 290 aids which the reviewing committees regarded as the best available for engineering educational purposes. The cost for the first 1000 bulletins will be $2.50 each. Inasmuch as the Committee has a reserve fund, collected from industry, to subsidize the initial printing, it was recommended that the price be set at $1.00 each. It was also recommended that 2000 copies be ordered in the initial printing.

Reports of Vice Presidents

Vice President H. K. Work reported that the ECRC will publish its Directory and Review of Current Research again this year and that it is also planning a publication of a compilation of papers on the general subject of Creativity in Research. The ECRC is providing helpful service to Directors of Research and Deans on the policy relationships between colleges and government in government sponsored research. A recent study on remuneration policies in research will be published in a forthcoming issue of the *Journal.* Dr. Renato Contini of New York University has been appointed Secretary of ECRC.

Vice President W. L. Everitt stated that the ECAC Executive Committee will meet during the Land Grant College Association meeting in November and therefore no plans have been drawn up for the forthcoming year. However, the various committees of ECAC including Manpower, International Relations, Selection and Guidance, and Secondary Schools are still active in various studies.

Vice Presidents Teare and Lassalle reported respectively on the Section activities and activities of Divisions and Committees. Most of these items are summarized elsewhere in the minutes.

Engineers' Joint Council

Dean Thorndike Saville, the ASEE representative on EJC and President of EJC, reported on the current activities of EJC. He mentioned that a number of amendments to the EJC Constitution and By-Laws had been proposed in order to strengthen the organizational structure of EJC. One of these would enlarge the pool from which the nominating committee of EJC could select its officers. This is essential in order to get the strongest possible people to serve as officers of EJC.

He reported that EJC is forging ahead in many of its important areas of investigation and that channels had been set up to disseminate information on what EJC is doing, so that the members of the constituent societies would be better informed. He mentioned that EJC will hold a symposium on nuclear engineering in the summer of 1955. This will be a collaboration of all of the constituent engineering societies, pooling their various papers in this field.

Life Membership

The General Council voted life membership for the following candidates who meet all the qualifications for membership in ASEE:

Allen, Chester
Christie, A. G.
Daniels, Joseph
Dolve, R. M.
Hastings, Hudson B.
Lohr, William S.
Lovell, A. H.
Rhodes, Sam R.
Savant, D. P.
Setchell, John E.
Trowbridge, D. S.
Turnbull, Wm. D.
White, A. E.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

THE T-SQUARE PAGE

CONTRIBUTIONS TO ENGINEERING EDUCATION
BY THE
DIVISION OF ENGINEERING DRAWING

T. T. AAKHUS, *Chairman*
University of Nebraska

HAROLD P. SKAMSER, *Secretary-Treasurer*
Michigan State College

WILLIAM E. STREET, *Vice Chairman*
A & M College of Texas

IRWIN WLADAVER, *Editor of*
the T-Square Page
New York University

How Important is Graphics to the Practicing Engineer?

By O. W. POTTER

Professor of Drawing and Descriptive Geometry, University of Minnesota

There has been a general trend in recent years to reduce the amount of drawing (graphics) in the engineering undergraduate curriculum. This has brought up many questions, such as: Is this a good thing for the overall training of the engineer? How far is this trend going to go? What does industry think about this? How does the practicing engineer feel about this?

I have been a practicing engineer and teacher for 39 years and I believe that drawing is important in the training of the engineer, and I also think that the proper place to teach it is in our engineering colleges with graduate engineers for teachers.

This past year I have been on sabbatical leave from the University of Minnesota making a study of the importance of graphics in the engineering profession. I have travelled around the country visiting engineering schools, industrial plants, and talking with many practicing engineers. Hundreds of questionnaires have been spread around the country with reference to this problem. The following quotations should be of interest to all in the engineering field. These come from practicing engineers of all ages, they are graduates of many different schools, come from many fields of engineering, all types of industry, and from all parts of the country. These were all received in 1953 or 1954.

Consulting Engineer, North Carolina.
"Impress on students the necessity of every engineer possessing the ability to make a clear concise drawing."

Consulting Engineer, Minnesota.
"Drawings are becoming increasingly more important."

Chief Products Engineer, Manufacturing Co., Ohio.
"Knock the silly idea out of the undergraduate that he is too good to be a draftsman, and that he will never need drawing."

Administrative Engineer, Aircraft Co., New Jersey.
"Creative design along with fundamental training in the principles of graphics should be given more emphasis."

Chief Mechanical Engineer, Steel Casting Co., Ohio.
"Drawings are at all times indispensable in engineering practice."

Chemical Engineer, Coke Manufacturing Co., Penn.
"Drawings are more important now than in former years."

Assistant Chief Engineer, Filtration Plant, Iowa.
"Stress that drafting is an important part of engineering; good designing engineers are in great demand. The fact that the drafting ability of many young engineers is not up to par is probably the main reason why they avoid drafting work."

Project Engineer, Manufacturing Co., Michigan.
"Drawings are more important now than in former years."

Chief Construction Engineer, General Contractors, Michigan.
"Drawings are of prime importance to all engineers."

Laboratory Supervisor, Public Utility, Michigan.
"Drawing is one of the basic tools of the engineer. It would be desirable to include some drawing in the senior year of the undergraduate course where the student could refresh his memory and techniques and apply what has been learned in mathematics, mechanics, and the specialized courses in his field."

Vic Pres., Consulting Engineers, Wisconsin.
"Drawings are extremely important and always will be."

Consulting Engineer, Virginia.
"Judging by our experience with recent young engineering graduates, there has been a decrease in emphasis on drawing in colleges. They have failed to recognize that the ability to prepare a clear drawing or read one is the tool of the engineer, and therefore a prerequisite to real success in that field, especially in design."

Structural Engineer, South Carolina.
"Drawing is absolutely indispensable to the practicing structural engineer."

Director of Research, Manufacturing Co., Mass.
"Drawing is so important as to demand the highest caliber of person for a teacher."

Sales Engineer, Manufacturing Co., Washington.
"It is my opinion that Engineering Drawing is one of the most important and useful courses that an engineer takes."

Design Supervisor, Manufacturing Co., New York.
"Engineers do make freehand sketches in both orthographic and pictorial form. They should know standards, specifications, shop practice, and descriptive geometry so they can supervise the detail draftsman."

Mechanical Engineer, Water Department of large city.
"Drawings are more important now than formerly."

Senior Civil Engineer, Consulting Firm, Texas.
"More actual drawing is needed."

Vice Pres. and Chief Engineer, Public Utility, Alabama.
"Cannot overemphasize the importance of drawing in the undergraduate program."

Assist. Section Mgr., Manufacturing Co., Indiana.
"Some engineering students seem to be given the impression in college that design drafting is a low level assignment. In my opinion, creative design as expressed in a drawing is as high a type of engineering as any."

Mechanical Engineer, Manufacturing Co., New York.
"Drawings are more important than formerly. Drawings are more complicated than formerly, better drafting is needed."

Engineer of Maps and Plans, Highway Department, Conn.
"It is a fact that we have to spend many hours teaching engineering graduates the simple fundamentals of neat draftsmanship directly after they leave the University."

Engineer, Manufacturing Co., New Jersey.
"Do not reduce the time allotted to drawing. Teach more descriptive geometry."

Electrical Engineer, Laboratory Supervisor, Manufacturing Co., Michigan.

"Include some drawing in the later part of the engineering course. Stress free-hand sketching and lettering."

Electrical Engineer, Airplane Mfg. Co., New Jersey.

"Don't lessen the amount of drawing. Creative design and fundamental training of principles should be stressed more."

Flight Test Engineer, Aircraft Co., California.

"Give more stress to assembly and detail drawings."

Consultant, Air Research Laboratory, Colorado.

"Dimensioning, detail and assembly drawing should be stressed more."

Designer, Chemical Co., Delaware.

"More drawing would be desirable."

Names of individuals and companies will be furnished on request.

In the News

A new plan to provide additional financial assistance for American colleges and universities through direct grants of funds was announced by trustees of the **General Electric Educational and Charitable Fund.** The new plan, known as the Corporate Alumnus Program, became effective January 1. It is the intent within limits of the plan that gifts will be made from the fund in amounts equal to those made by G-E employed alumni during 1955. In announcing the plan, Philip D. Reed, Chairman of the G-E Board of Directors and chairman of the Fund's trustees, said the plan "is thought to be unique in business-education circles because it provides for joint participation in the giving program by individual employees who are college graduates, and by the Educational Fund."

Mr. Reed estimated the company employs some 23,000 college graduates with earned degrees from more than 540 U. S. colleges and universities. He said contributions of any such college graduate, up to $1,000 within the year, will be eligible for contributions from the Fund.

The plan further stipulates that contributing employees must have at least a year's service with the General Electric Company; the contributions must be an actual gift and not merely a pledge; and it must be made to an accredited U. S. college or university of which the contributor is an earned degree holder. Mr. Reed said the trustees will consider at the end of 1955 whether the program should be extended, and whether experience has indicated changes that might improve it.

The Corporate Alumnus Program was described by Mr. Reed as "frankly an experiment, arrived at after long consideration of the whole subject of business support for higher education." The trustees of the General Electric Educational and Charitable Fund, he explained, are strongly convinced that one of the greatest untapped sources of continuing support for higher education lies in regular contributions by alumni. With the backing and cooperation of the General Electric Company, the trustees decided that a "corporate alumnus" program, with its provisions for joint action by the alumni and the fund, would do the most to stimulate colleges and universities to develop their own alumni-giving programs and thereby help themselves.

"It is clear that the one who profits most from education is the individual graduate, but undeniably the benefits are shared by the organizations with which he is associated," Mr. Reed said. However, he explained, "in almost every instance, the real cost of a college education was not covered by the tuition paid—usually not more than half of it, in fact. It seems appropriate and fair, therefore, that both the individual and the organization with which he has allied himself should undertake some measure of support for the colleges and universities which play so important a role in American life and progress so that others can participate in those benefits."

Continuing, Mr. Reed said, "this proposition is especially challenging right now, when institutions of higher education are facing higher costs, increased enrollments, and greater demands for educated manpower on the part of industry, science, the professions and government. Their problem is complicated by inadequate or outmoded facilities in many cases, and by overworked teaching staffs which are almost always underpaid."

The G-E board chairman said "it is the hope that other companies may find in this idea an appropriate pattern for incorporation in the educational programs in which they are interested."

New Members

ANGAS, WILLIAM M., Chairman, Department of Civil Engineering, Princeton University, Princeton, N. J. Philip Kissan, F. A. Heacock.

ARMENAKAS, ANTHONY E., Lecturer in Civil Engineering, City College of New York, New York, N. Y. H. G. Lorsch, J. R. Steven.

BAREUTHER, CHARLES A., Head of Physics Department, Drexel Evening College, Philadelphia, Pa. K. W. Riddle, W. J. Stevens.

BARTLETT, ALBERT A., Assistant Professor of Physics, University of Colorado, Boulder, Colo. L. G. Tulin, C. L. Eckel.

BISCHOFF, FREDERICK B., Instructor in Engineering, Lowell Technological Institute, Lowell, Mass. Milton Hindle, M. E. Gelinas.

BISPLIAGHOFF, RAYMOND L., Professor of Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. S. Draper, J. A. Hrones.

BOLING, RONALD W., Instructor in Industrial Engineering, University of Tennessee, Knoxville, Tenn. R. M. LaForge, H. P. Emerson.

BRENNER, EGON, Lecturer in Electrical Engineering, The City College of New York, New York, N. Y. Vincent Deltoro, G. J. Clemens.

BYERS, ROLAND O., Assistant Professor of Civil Engineering, University of Idaho, Moscow, Idaho. M. L. Jackson, L. B. Craine.

CLIFFORD, PETER C., Instructor in Building Construction, New York State University, Agricultural and Technological Institute, Delhi, N. Y. F. E. Almstead, W. H. Branch.

CLUTE, VERNON G., Instructor in Machine Shop and Mechanical Drawing, Hudson Valley Technical Institute, Troy, N. Y. O. V. Guenther, J. L. DeLee.

COLES, HENRY L., Head, Department of Chemistry and Chemical Engineering, Michigan College of Mining and Technology, Houghton, Mich. R. F. Makens, M. W. Bredekamp.

DAASCH, HARRY L., Professor and Head of Mechanical Engineering Department, Colorado A. & M. College, Ft. Collins, Colo. D. N. Zwiep, H. B. Mummert.

DATSKO, JOSEPH, Assistant Professor of Production Engineering, University of Michigan, Ann Arbor, Mich. K. E. H. Moltrecht, W. C. Truckenmiller.

EDMONDSON, JAY N., Professor of Industrial Engineering, The Ohio State University, Columbus, Ohio. H. D. Moore, G. B. Carson.

ESHER, FREDERICK N., Assistant Professor of Engineering, Pennsylvania State University, State College, Pa. K. L. Holderman, V. E. Neilly.

FENSTER, SAUL K., Lecturer in Mechanical Engineering, City College of New York, New York, N. Y. H. A. Rothbart, S. J. Tracy.

FULTON, PAUL F., Associate Professor of Petroleum Engineering, University of Pittsburgh, Pittsburgh, Pa. H. G. Botset, W. R. Turkes.

GOODSPEED, HENRY S., JR., Instructor in Mechanics, Lafayette College, Easton, Pa. W. R. Ferrante, W. G. McLean.

GROEN, JOSEPH M., Instructor in Mechanics, Missouri School of Mines, Rolla, Mo. R. F. Davidson, R. A. Schaefer.

HALE, HARRY W., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Indiana. G. V. Mueller, L. E. Beck.

HALLER, KURT, Instructor in Physics, Newark College of Engineering, Newark, N. J. M. R. Weller, T. J. Blisard.

HICKEY, WILLIAM A., Dean of Engineering, Detroit Institute of Technology, Detroit, Mich. E. J. Taylor, P. H. Black.

HILLERY, ARCHIE V., Instructor in Civil Engineering, Ohio Northern University, Ada, Ohio. A. D. Taylor, L. H. Archer.

HUFFMAN, HOWARD L., Instructor in Industrial Engineering, Montana State College, Bozeman, Montana. E. W. Schilling, S. A. Whitt.

HUNT, WILLIAM T., JR., Assistant Professor of Electrical Engineering, City College of

New York, New York, N. Y. H. B. Hansteen.

KEIM, PAUL F., Professor of Civil Engineering, University of California, Berkeley, Calif. A. S. Chase, Bruce Jameyson.

KNOWLTON, CHARLES F., Lecturer in Engineering, University of California, Los Angeles, Calif. C. M. Duke, P. F. O'Brien.

LEHMAN, FREDERICK G., Assistant Professor in Civil Engineering, Newark College of Engineering, Newark, N. J. W. S. LaLonde, Jr., J. M. Robbins.

LEVINE, MARTIN, Instructor in Electrical Engineering, Pennsylvania State University, State College, Pa. K. L. Holderman, V. E. Neilly.

LIEBERMAN, GERALD J., Assistant Professor of Statistics and Industrial Engineering, Stanford University, Stanford, Calif. B. M. Green, E. L. Grant.

LORELL, WILLIAM W., Lecturer in Civil Engineering, City College of New York, New York, N. Y. H. G. Lorsch, J. R. Steven.

MAGNUSSON, LLOYD R., Instructor in General Engineering, Purdue University, Lafayette, Ind. K. E. Botkin, H. C. Thompson.

MAHONE, LESLIE W., Associate Professor of Civil Engineering, University of Arkansas, Fayetteville, Ark. L. R. Heiple, G. F. Branigan.

MCCULLOCH, FRANK W., Manager—Employment and College Relations—Corporate Staff, Radio Corporation of America, Camden, N. J. B. R. Teare, Jr., J. W. Graham.

MCGRAW, JAMES L., Instructor in Technical Institute, University of Dayton, Dayton, Ohio. D. C. Metz, A. J. Morgan.

MCGUIRK, DONALD R., College Employment Coordinator, New York Telephone Company, New York, N. Y. D. S. Bridgman, W. E. Foltz.

MENTZ, PHILIP S., Instructor, Department of Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, J. H. Porsch.

MERWIN, JOHN E., Instructor in Civil Engineering, The Rice Institute, Houston, Texas. J. R. Sims, L. B. Ryon.

MIDDENDORF, WILLIAM H. H., Assistant Professor of Electrical Engineering, University of Cincinnati, Ohio. H. K. Justice, W. E. Restemeyer.

MILBANK, REGINALD V., Professor and Chairman of Civil Engineering, University of Vermont, Burlington, Vt. S. C. Knight, Jr., E. R. McKee.

NEWCOMB, BRADLEY L., Assistant Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn.

O'DELL, CHARLES W., Lecturer in General Engineering, University of Southern California, Los Angeles, Calif. G. T. Harness, R. E. Vivian.

ROBERTS, DAVID G., Instructor in Product Engineering, General Motors Institute, Flint, Mich. H. M. Dent, C. L. Tutt, Jr.

RUEVE, STEPHEN J., Regent of the College of Engineering and Professor of Philosophy, Marquette University, Milwaukee, Wis. R. J. Panlener, J. E. Matar.

SAVANT, CLEMENT J., JR., Associate Professor of Electrical Engineering, University of Southern California, Los Angeles, Calif. G. T. Harness, R. E. Vivian.

SKORAN, THOMAS E., Instructor in Engineering Graphics, Purdue University, Lafayette, Indiana. W. J. Luzadder, K. E. Botkin.

SOMMERS, B. KLARE, Head of Division of Building Construction, New York State University, Agricultural and Technological Institute, Delhi, N. Y. F. E. Almstead, W. H. Branch.

TUMEINSKI, RONALD F., Instructor in Chemical Engineering, Lafayette College, Easton, Pa. E. L. McMillen, Z. D. Jastrzbski.

VANDERRYN, JACK, Graduate Assistant in Chemistry, Lehigh University, Bethlehem, Pa. G. J. Christensen, E. K. Muhlhansen.

VAN HAM, LOUIS A., Head of Drafting Department, Boston Technical High School, Boston, Mass. E. H. Temple, William Bettencourt.

WAKELAND, HOWARD L., Assistant Dean, College of Engineering, University of Illinois, Urbana, Ill. W. E. Miller, S. H. Pierce.

WALSH, EDWARD J., Executive Director, Foundry Educational Foundation, Cleveland, Ohio. C. J. Freund, G. K. Dreher.

WEINLAND, LOUIS A., Assistant Professor of Chemistry, State University of New York, College of Ceramics, Alfred, N. Y. R. M. Campbell, W. J. Sutton.

263 new members elected this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 17, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Brooklyn Polytechnic Institute	Dec. 4, 1954	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

Young Engineering Teachers' Paper Contest

RULES

Eligibility: Members of ASEE who are not over 35 years of age (their 36th birthday must not be before June 1, 1955).

Awards: First prize $200—Second prize $100.
Honorable mentions as determined by the Judging Committee.

Presentation of Awards: The awards are known as the "President's Awards." They will be presented to the recipients by the President of the Society at the Annual Banquet at Pennsylvania State University, June, 1955.

Subject: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to use their own judgment in selecting appropriate subject matter.
The following are suggestions of possible subjects:

1. Professional development of the Young Engineering Teacher.
2. How should the student be helped to learn to deal with situations that are new to him, on his own initiative and with well-ordered professional thinking?
3. To what extent should modern physics be included in the engineering curriculum and how should this be done?
4. What areas of physics, chemistry, mathematics and biology not now taught in engineering curricula are likely to be translated into significant engineering practice in the next 25 years and how should this influence present curricula?
5. To what extent and in what manner should undergraduate instruction acquaint the engineering student with the methods of research and with recent research developments in engineering and closely allied sciences?
6. What should be taught of the art of engineering as contrasted with its science?
7. What basic science, mathematics and communication principles and skills can best be taught by separate department staffs and what part by integration into engineering courses?
8. What can be done in college to prepare the young engineer to continue to learn after his formal education is ended?
9. How should non-major courses in engineering such as electrical engineering for non-electricals be planned as to content and method?

Length of Paper: Not to exceed 2500 words.

Submission of Entries: All entries should be submitted to the Chairman of the ASEE Section in which the member resides before March 1, 1955. Names and school affiliations of Section Chairmen are published each month on the page in the Journal of Engineering Education designated "Section Meetings." Papers submitted in the contest last year or in other contests are not eligible for this year's contest.

Judging: Each Section of ASEE will appoint a Judging Committee to select the best paper from the Section. This paper will be submitted to the ASEE Secretary before April 1, 1955.

The winning papers from the various ASEE Sections will be submitted to a Final Judging Committee for the final selection.

Here is an opportunity to gain national distinction. Good luck!

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1955 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(*In Charge of General and Regional Activities—two years*)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Sections and Branches

The Winter Meeting of the Middle Atlantic Section of A.S.E.E. was held December 4, 1954 at the Polytechnic Institute of Brooklyn.

The theme of the general meetings was the integration of the humanistic subjects into an engineering curricula. The speakers and their topics were:

Dr. A. S. Adams, The Role of the Humanities in Engineering Education.
Pres. E. S. Burdell, The Humanities and the Social Studies in the Engineering Curricula.
Dr. J. G. Cavanna, The Humanities in Relation to Science and Engineering at the Polytechnic.

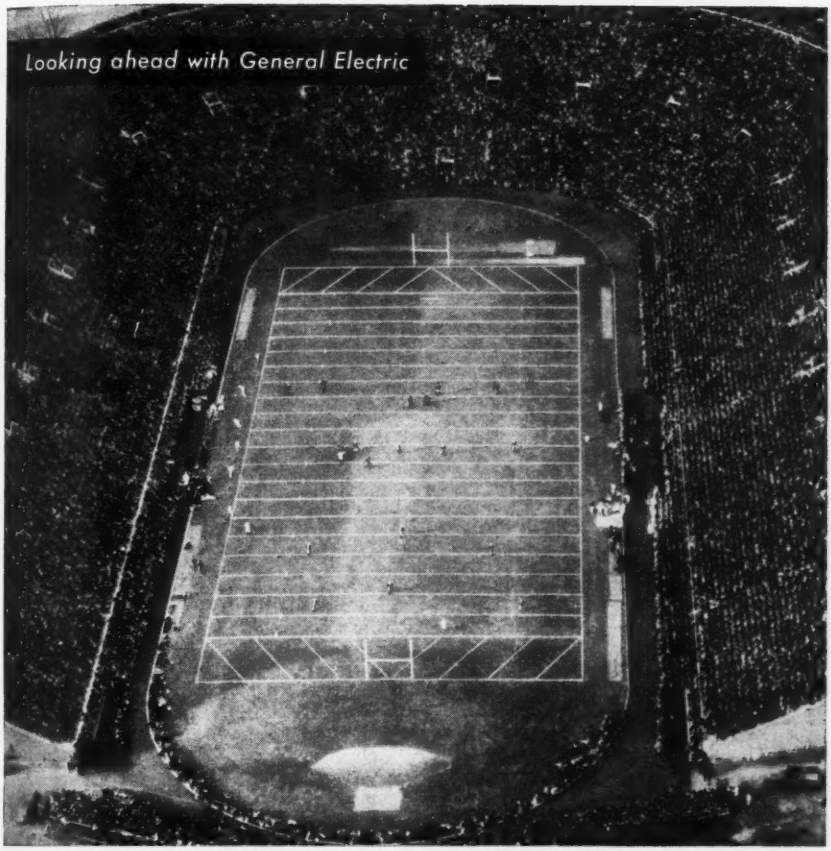
Most of the afternoon was devoted to five group meetings with the following topics:

A. How Shall Modern Scientific Developments Affect the Undergraduate Curricula?
B. How the Old Timers Can Help the Younger Staff Members.
C. Should a Major Research Program, Financed by Industry, Be Undertaken in the Power Field?
D. Thesis?
E. A Workshop for the Humanities and the Social Studies.

Report of the Nominating Committee, Prof. G. B. Thom presented the following names:

Professor C. C. Carr, Chairman, Pratt Institute.
Mr. R. F. Bitner, Vice Chairman, Prentice-Hall, Inc.
Dean D. L. Arm, Member of Council, Univ. of Delaware.

The above members were elected.



45,000 G-E people working on jobs created by new products since 1945 could almost fill Princeton's Palmer Stadium.

In 9 years, new products created G-E jobs for enough people to fill a football stadium

Coming years promise even more progress.

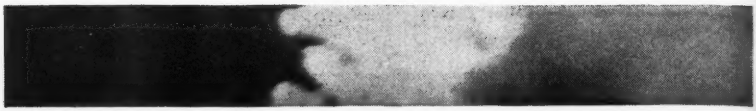
One out of every five people at General Electric owes his job to products G.E. didn't make before 1945. And the future looks even brighter.

We can see new and exciting possibilities in many different fields. Atomic energy, jet engines, electronics, silicones—all promise to create new products, new processes, and new jobs.

As we see it at General Electric, America's industrial progress in a free economy is not only continuing, it's rapidly accelerating.

Progress Is Our Most Important Product

GENERAL ELECTRIC



For TV...it dodges trouble you can't stop

Radio Relay station on route between Chicago, Ill., and Des Moines, Iowa. Every fifth or sixth relaying tower is a control station, where high-speed switching equipment enables a TV picture to skip out of a troubled channel and into a stand-by protection channel faster than the eye can wink.

There's no way to stop atmospheric changes that threaten television with "fade." But, for TV that travels over Bell's Radio Relay System, Bell Laboratories engineers have devised a way to sidestep Nature's interference.

When a fade threatens—usually before the viewer is aware—an electronic watchman sends a warning signal back by wire to a control station perhaps 200 miles away.

An automatic switching mechanism promptly transfers the picture to a clear channel. The entire operation takes 1/500 of a second. When the fade ends, the picture is switched back to the original channel.

This is an important addition to the automatic alarm and maintenance system that guards Bell's Long Distance network for television and telephone calls. It marks a new advance in Bell Laboratories' microwave art, developed to make your Long Distance telephone service, and your TV pictures, better each year.

BELL TELEPHONE LABORATORIES

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS

Which Oscillator for You...

BFO or RC?

Three decades ago, G-R was the first to make the Beat-Frequency Oscillator widely available for use by the engineering profession. The basic RC Oscillator patent is also held, with 34 claims, by the General Radio Company. Today, G-R manufactures both Resistance-Capacitance Oscillators and Beat-Frequency Oscillators . . . two RC instruments and four BFO's, each intended for reliable service in one or more particular areas of application.

You can see we're not partial to either design. It does seem though, that the rapid acceptance of the RC generator over the last decade has led many to overlook the merits of the Beat-Frequency Oscillator. We feel it's high time to review the many basic advantages of this general-purpose signal source.

The G-R Type 1304-B Beat-Frequency Oscillator . . . a basic laboratory tool. Frequency range from 20 to 40,000 cps – frequency-increment dial permits close adjustments of frequency, one cycle at a time – drift from cold start is less than 3 cps in the first hour, is essentially complete in two hours – distortion is minimum, less than 0.25% from 100 to 10,000 cyles, 0.5% at 50 cycles, and no more than 1% above 10 kc – meter and calibrated output attenuator included. . . . . **Price: $555**

ADVANTAGES OF THE BEAT-FREQUENCY OSCILLATOR

Rapid Coverage — one complete turn of the dial, adjusts frequency over the entire range; this very useful feature permits rapid frequency-response investigations on all types of equipment — because the RC oscillator does not provide sufficient frequency overlap when switching from band to band, measurements at dial extremes can be very inconvenient and time consuming.

Constant Output Level Over Entire Range — an extremely important BFO characteristic which greatly facilitates frequency-response testing, eliminating need for constant adjustments — output level is not subject to discontinuities resulting from band switching as necessary with the RC oscillator.

Good Stability — the internal BFO fixed and variable oscillators are similar in construction so that temperature changes and supply voltage variations affect both sections by the same amount and tend to cancel — at 1 kc, typical drift of the BFO from cold start is less than 10 cps; this is easily corrected with a simple zero adjustment so this potential error is reduced to essentially zero — a good RCO has about the same drift but no control for correction.

Distortion Is Low — BFO waveform can be made almost entirely dependent on the waveform of its *fixed-frequency* source, which is easily kept free from distortion — representative distortion figures at 1000 cycles are 0.5% for the BFO, 1% for the RCO.

Long Term Calibration — accuracy of calibration of BFO depends upon the long-term stability of inductors rather than of resistors and is therefore inherently more reliable — the BFO can also take advantage of the inherent stability resulting from a low L to C ratio.

Logarithmic Frequency Control — the BFO has an outstanding advantage for audio-frequency testing; its frequency dial can be calibrated logarithmically over several decades — in the case of the G-R Type 1304-B, the dial drive can be connected directly to a recorder for the automatic recording of frequency response over a range of 20 to 20,000 cps *without range switching*. The RC oscillator usually requires three bands to cover this range.

Much has been made of the low-frequency limitations of the Beat-Frequency Oscillator where the RC circuits are definitely superior. But, in fairness, it should be said that a similar problem exists with the RCO since the tuning capacitor must operate above chassis potential, which may cause "lock in" at power-line frequencies and multiples thereof.

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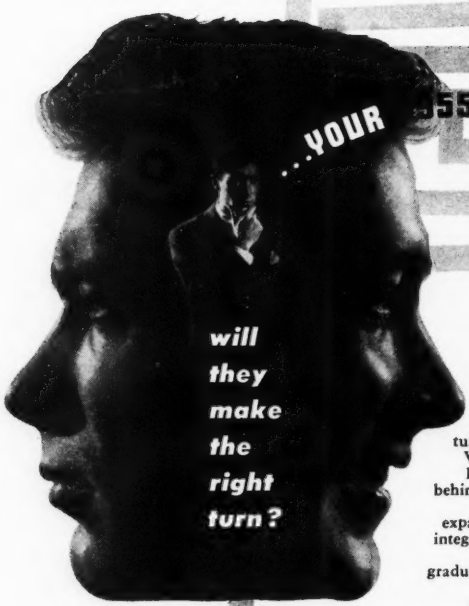
INFORMATION
If you or any of your students would like additional information about engineering careers at Boeing, write to John C. Sanders, Staff Engineer-Personnel, Boeing Airplane Company, Seattle 14, Washington.



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